THE SCIENCE OF Remote Learning

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Beta Version

About The Science of Remote Learning

The purpose of *The Science of Remote Learning* is to

- summarize key concepts from cognitive science research
- connect these concepts to strategies and practices for remote teaching and learning
- help move beyond the first iteration of emergency instruction in response to the Covid-19 pandemic toward increasingly effective remote learning and online courses.

This resource is written in plain language to be broadly applicable to professional educators and non-professionals: teams designing remote learning experiences, people supporting at-home learning including parents, and learners at any level (if they have the prior knowledge to comprehend the text.)

The Common Education Data Standards define virtual instruction as *"instruction in which students and teachers are separated by time and/or location and interact through the use of computers and/or telecommunications technologies."*[1]

The Science of Remote Learning is a synthesis and adaptation of existing resources and contributor insights. It draws heavily on the following resources:

- Goodell, Kolodner, Ritter, Kessler [in press]. Learning Sciences Game Cards. IEEE ICICLE 2019 Conference on Learning Engineering.
- Deans for Impact (2015). The Science of Learning. Austin, TX: Deans for Impact.
- Digital Promise Research Map.
- Yancy McGuire, S. (2018). Teach Yourself How to Learn: Strategies You Can Use to Ace Any Course at Any Level.

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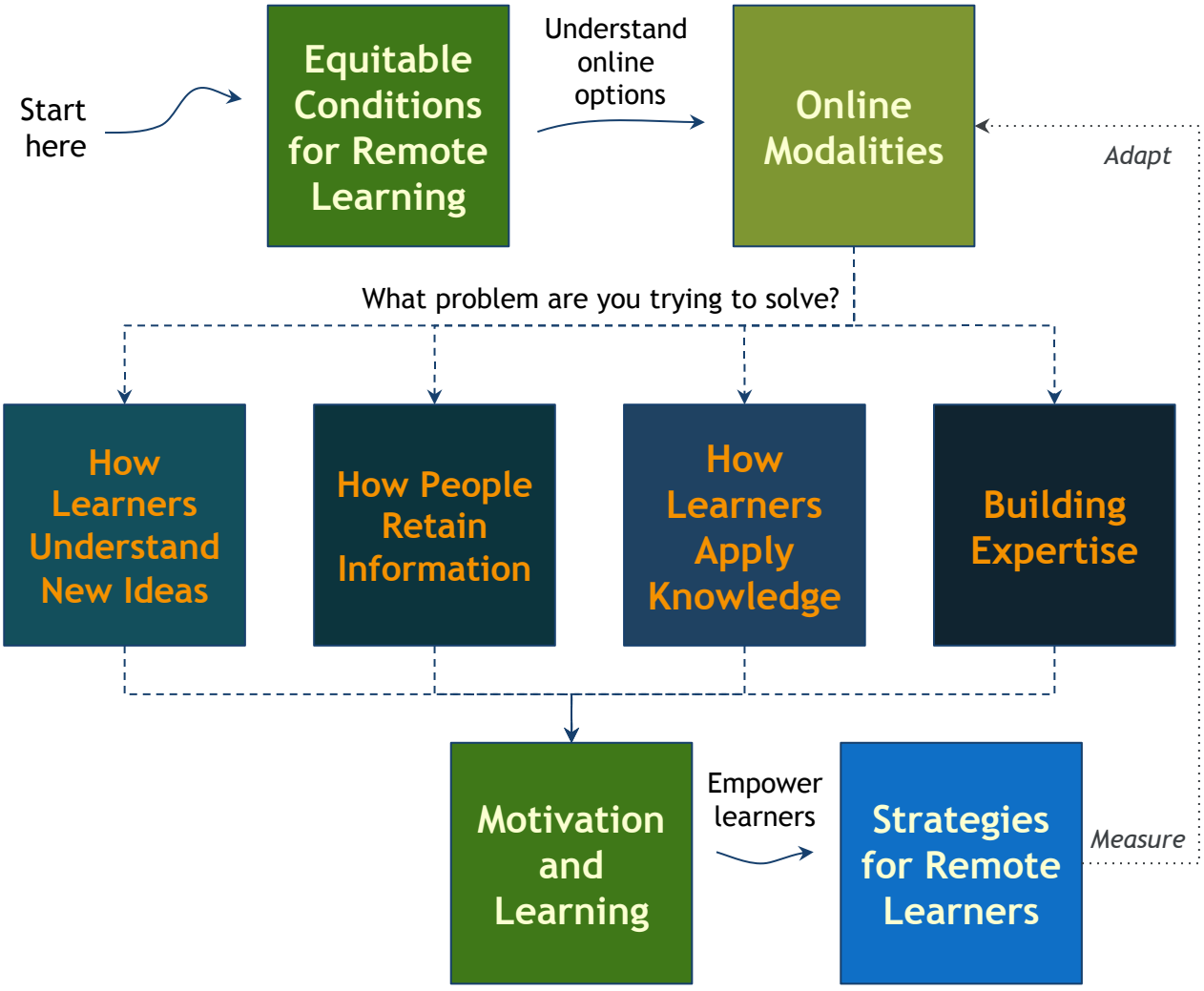
[1]https://ceds.ed.gov/

Learning is a Process that Requires Different Strategies at Different Times

Learning is not something done to students by a teacher. It is a process in the learner's brain of adding and changing existing knowledge. Learning only happens if the learner actively participates in the learning process.[1, 2]

(Click/tap/scroll to the following pages with insights on themes within remote teaching or learning.)



If you are interested in more information related to learning we recommend:

How People Learn II: Learners, Contexts, and Cultures

How People Learn: Brain, Mind, Experience, and School

[1] Freeman, et al., 2014

[2] Bransford, Brown, & Cocking, 2000

Equitable Conditions for Remote Learning

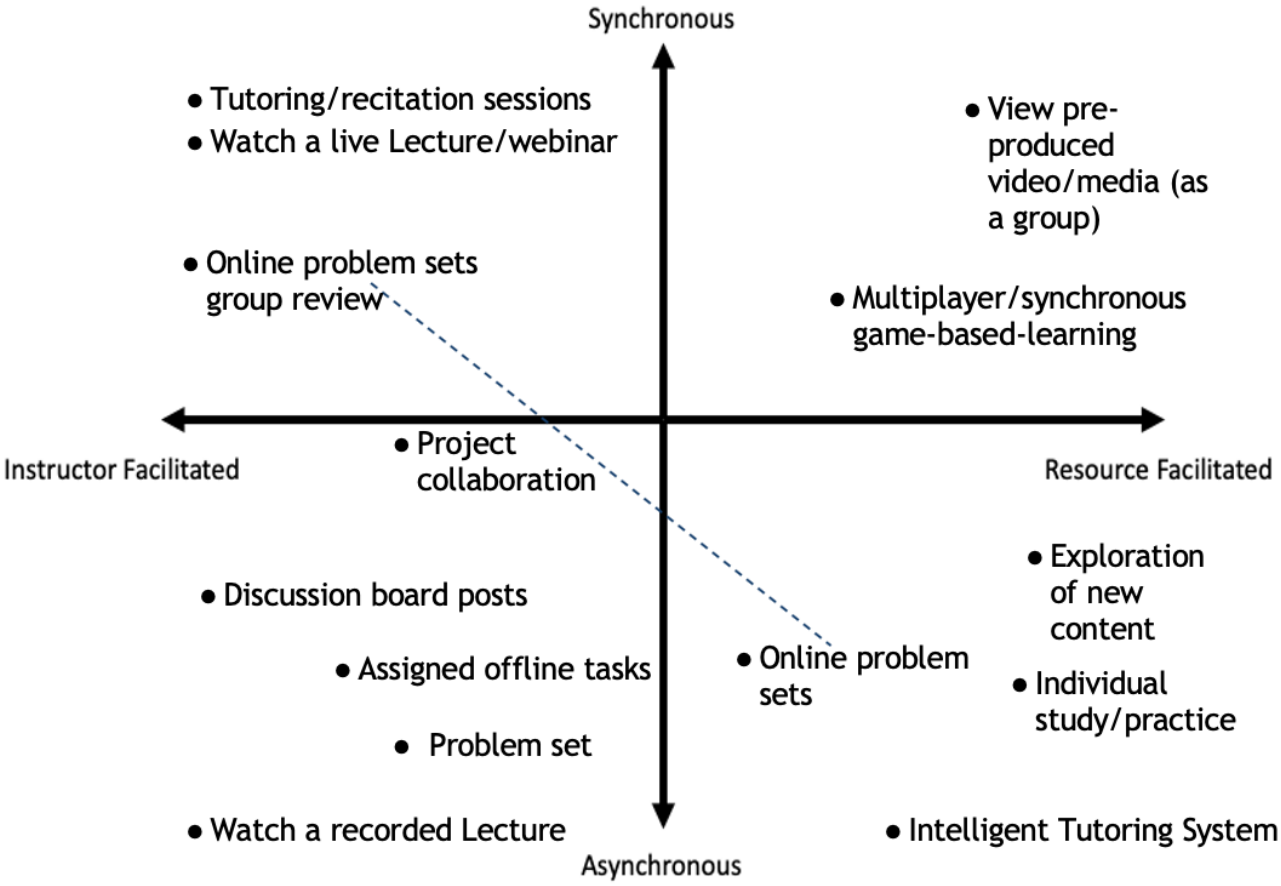
STRATEGIES	PRINCIPLES

• Ensure that every student has a connected device:
  ○ consider re-allocating physical facility funds, e.g. heating and cooling buildings
  ○ loan existing devices to students
  ○ K12 schools with WiFi-enabled busses are parking them strategically
  ○ work with local internet providers and external funders to offer free or low cost hotspots to those in need
  ○ every student should have a device (not 1 per family)
• In the short term, create alternate approaches to online learning (printed materials and phone calls.)[1]
	Inequities exist in levels of access to remote learning including:
	• connectivity and devices
	• learning contexts
	• learning resources
	• family-school communication channels
	Brick and mortar schools work to ensure students of all income levels and situations get to class (e.g. busses, truancy laws, Pell grants, community college commuter parking lots) and get needed services. For remote learning "attendance" means connectivity, devices, daily schedules or check-ins, and a virtual learning environment. Families and homes become part of the learning context.

• Design remote learning to interact with culture and expectations in the home and community of each learner. • Build an intentional culture that is conducive to learning goals.[2] • Redefine professional roles/collaborations accordingly.	Culture is the learned habits of practice of of a group of people that generally reflects socially transmitted traditions. Understanding the cultural, contextual, and historical diversity of learners is central to understanding how people learn.[5]
• Develop new strategies and staffing plans to support remote English learners and their families. • Retrain/re-equip paraprofessionals as virtual learning coaches. • Assess needs for every learner in the remote learning context. • Curate for learner variability [3,4]	Some learners need more or different supplemental support than others. Some students who thrive in physical schools struggle with remote learning. Just like brick and mortar schools remote learning must provide accommodations and supports for those with disabilities, special needs, and language learners.
See "Motivation and Learning" and "Strategies for Remote Learners" in this document.	Learner agency is critical in remote learning.

[1] NAACP, 2020
[2,5] NASEM, 2018
[3] CAST, 2018
[4] https://lvp.digitalpromiseglobal.org/

Online Modalities



These are only examples, not a comprehensive list of modalities.

There are many modalities of online and remote learning. The plot above is a way to understand where learning activities fall on the spectrums of Synchronous (in real time and usually together) vs. Asynchronous (anytime and usually independently) and Instructor Facilitated vs. Resource Facilitated.

A number of factors should be considered when deciding on the best modality for engaging learners in specific content. These include:

- What are the instructor facilitated and resource facilitated options that will best address each learning objective and the needs of each learner?
- Consider the range of activities that might be done synchronously with a group of students (e.g. webinar or group discussion), or asynchronously either with a group (e.g. discussion thread) or individually (e.g. intelligent tutor - practice with feedback) and, if possible, give students multiple opportunities to engage with learning objectives across modalities.
- Recognize that instructor time is a limited and valuable resource.
- Consider the context in which learning will take place including the platform on which your students will interact with online resources, availability of any physical resources needed for the activity, and home schedules.
- Whenever possible connect local and family priority and values to school subjects like biology, chemistry, history, etc.

How Do Learners Understand New Ideas

TEACHING AND LEARNING STRATEGIES	COGNITIVE PRINCIPLES
• Learning sequences should be ordered to consider the prior knowledge that a learner needs to make sense of new concepts.[1] • Assess prior knowledge to inform effective use of time and energies in ways that will be most productive. • Use analogies to help map new ideas onto those a learner already knows.[2] • Use frequent low- or no-stakes quizzing to measure learning progress and allow learners to reflect on progress.[3]	People learn new ideas by reference to ideas they already know.[5]
• Use multiple modalities to present and represent new ideas; for example, show a graphic representation of an abstract model or provide a video with an audio description. • Worked examples are step-by-step demonstrations of how to perform a task or solve a problem. This guidance ("scaffolding") can be gradually removed in subsequent problems so that learners complete more problem steps independently.[4]	To learn, a person must transfer information from working memory (where it is consciously processed) to long-term memory (where it can be stored and later retrieved).
• Learners can adopt strategies to manage cognitive load, such as writing or recording steps of a math problem rather than trying to solve the problem in their head. • Simplify content, images, and video to be focused on pertinent information • Focus students attention to important features of complex ideas and representations.	People have limited working memory capacities. Too much new information at once can be overwhelming.[6]
• Offer/use alternative learning content and paths. • Determine that a learner is ready for a new concept based on whether they have mastered a prerequisite, not based on a fixed age.	Mastering new concepts happens in fits and starts. People learn at different paces and by different paths. There isn't one fixed sequence of age-related stages that apply to everyone.[7]

[1,6] Sweller, 1988
[2] Richland, Zur, & Holyoak, 2007
[3] Roediger & Butler, 2011
[4] Renkel, 2014
[5,7] Bransford, Brown, & Cocking, 2000

How People Retain Information and Abilities

TEACHING AND LEARNING STRATEGIES	COGNITIVE PRINCIPLES
• Provide low stakes assessments over time to check for decay and encourage retrieval (e.g. weekly quizzes and practice exams). • Over time, build on initial understanding by applying the knowledge to new contexts for retention and deeper understanding. • Encourage students to test their own understanding and reflect on what they do not know in order to re-engage with content.	The ability of a person to recall previously learned information often decays over time. When the information is retrieved periodically (remembered and used in a purposeful way) the long term ability to remember increases.[1]
• Spread out learning sessions for a new concept or idea over time, rather than all at once. • Ground new concepts by reviewing previously learned material and making clear how the two connect. • Use online practice tools that optimize spacing of practice sessions, e.g. tutoring systems. • Practice with intentional goals in order to improve recall of facts or improve performance of a skill.	Repeated exposure and practice is essential to learning new facts and competencies, but not all practice is equivalent. People tend to remember things more effectively if they use short focused study periods spread out over time and that are connected with other related concepts.[2]
• Have learners consider what strategies are being applied to solve a problem and why? • Concept maps, curricular flow charts, and competency maps can provide learners with representations of how abstract ideas are connected.	New concepts are more likely to be retained when learners think about why the information is important and what it means.
• Provide scaffolding including hints, prompts, conceptual frameworks (e.g. advance organizers), process support, focus support, and strategic guidance. • Provide just enough support to make tasks achievable without losing useful complexity or context.	When constructing buildings scaffolding is added so workers can reach higher, and then removed when no longer needed. Likewise, “scaffolding” for learning may be added and removed based on each learner’s current needs.[3]

[1] Roediger & Butler, 2011
[2] Roediger & Pyc, 2012
[3] Wood, Bruner, & Ross, 1976

How People Learn to Apply Knowledge

TEACHING AND LEARNING STRATEGIES	COGNITIVE PRINCIPLES
• Tasks students are asked to complete should require them to connect procedural (the how of solving task) and conceptual (the why) knowledge.[1] • Tasks with higher levels of cognitive engagement require students to move beyond memorization.[2] • These tasks often require more time to complete and may need multiple cycles of feedback before they are completed. • While all tasks do not need to be at a high level, building opportunities for learners to do this work within a unit of content can produce deeper understanding.	Deep levels of cognitive engagement require more authentic and conceptual use and application of knowledge and skills to complete learning tasks.[5]
• Frame passive learning materials (e.g. videos and readings) with concept questions or prompts that encourage students to think critically about the information they are learning. • Limit the time between student thinking and action (e.g. short videos with questions interspersed rather than long videos) • Structure examples, problems, and projects in as authentic a context as is appropriate for the age and background of the learners.[3] • Encourage students to actively discuss ideas, ask questions, and share knowledge through structured sessions.[4]	Students strengthen understanding of ideas and are able to more flexibly apply knowledge when required to actively and authentically engage with content instead of just passively receiving information.

[1, 5] Freeman, et.al., 2014
[2] Van Merrienboer, Clark, & Croock, 2002
[3] Bransford, Brown, & Cocking, 2000
[4] Kirshner et al., 2018

Building Expertise

TEACHING AND LEARNING STRATEGIES	COGNITIVE PRINCIPLES
Feedback...[1, 2] • needs to be timely in order for students to remember the ideas and work addressed in the original assignment. • should allow learners to make sense of information. • should include opportunities for the learner to take action and demonstrate deeper understanding. • from instructor can be multi-modal (e.g. spoken or text-based instructions using visual aid or demonstration).	Compared to novices, experts not only have much more content knowledge but also have organized that knowledge for deeper understanding, rapid retrieval, and contextual application. Experts can see patterns and understand under which conditions and contexts to apply knowledge. Experts can select and retrieve important aspects of their knowledge without effort. That takes intentional practice with feedback.[4]
• Students need opportunities to work collaboratively on solving complex tasks that require application of knowledge not just demonstrating memorization of ideas. • Learning Communities require (physical or virtual) spaces and scaffolds to work on problems. They also need established (usually community developed) sets of norms and process to achieve their goals.	Learning communities (grounded in Communities of Practice) allow students to socially situate and construct knowledge.[5,6]
• Similar to worked examples, provide learners with explanations of work that utilizes previously learned ideas and skills to complete tasks. • Mentors need to allow mentees opportunities to engage in increasing levels of approximations of work (complexity).[3]	Mentorship through modeling of ideas and skills while engaging in real world activities allows novice learners to begin developing expertise.

[1] Henderson & Phillips, 2015
[2] http://newmediaresearch.educ.monash.edu.au/feedback/
[3] Grossman et al., 2009
[4] Bransford, Brown, & Cocking, 2000
[5] Lave, & Wenger, 1991
[6] Wenger, 1998

Motivation and Learning

TEACHING AND LEARNING STRATEGIES	MOTIVATION PRINCIPLES
• Make sure resources are made available to meet learners' basic needs and check in regularly with those most at risk. • Structure the learning to encourage learner agency and an environment where learners feel comfortable taking appropriate chances.	Before engaging higher levels of motivation, a person's basic survival needs (e.g. not starving, feels safe) and psychological needs (e.g. belonging, esteem) must 'more or less' be met.[3]
• Help learners understand that many aspects of learning, including strategy and effort, are under their control. • Help learners see failure as an opportunity to find out what they do not know (and adjust their learning strategies accordingly), rather than as an indication of self-worth.[1]	Learning is not something done to students by a teacher. It is a process in the learner's brain of adding and changing existing knowledge. Learning only happens if the learner actively participates in the process. Learners are more likely to persevere if they believe their talents can be developed through hard work, good strategies, and input from others.[4,5]
• Use multiple motivational strategies to tap into core drives. • Make explicit the reason for selected work and how it will support students learning. • Give learners opportunities to write and reflect on interests and connectedness with content.[2]	People are motivated by different things at different times. Motivators fall into these categories: • Meaning • Accomplishment • Ownership • Scarcity • Avoidance • Unpredictability • Social Influence • Empowerment
• Make learning activities personally meaningful, authentic, and connected to prior knowledge. • As much as possible and appropriate, give learners the option to select projects and activities.	Learners are more likely to be motivated if they feel capable, know when and who in the world carries out such tasks, have resources that someone in the real world engaging in that task would have, and if activities and assessments fit into the flow of what they are trying to achieve.

[1] Rowland, 2014
[2] Hulleman et al., 2010
[3] Maslow, 1943
[4] Freeman, et al., 2014
[5] Bransford, Brown, & Cocking, 2000

Strategies for Remote Learners

Establish Norms and Routines

- ❑ Keep track of your weekly schedule in one place (this can be an electronic or paper calendar, online task management tool or app, a journal, a task board).
- ❑ Keep track of all important dates and assignments in one place
- ❑ Determine when specific work will be completed (synchronous sessions, project work, turning in assignments) and develop a plan for how you will accomplish these.
- ❑ Work with others in your setting (family, roommates, pets) to determine what is needed to learn. (Is quiet time needed during certain times of the day? When will you need access to certain resources (computer) to do your work? Should a specific area be dedicated to working on lessons?

Self Monitoring

- ❑ Time and Task Management - Set specific times when you will work on specific assignments. Close non-essential programs to work on specific work. Chunk your work time into shorter yet focused intervals.
- ❑ Check your understanding with frequent quizzes. Analyze wrong answers to figure out gaps in your learning.
- ❑ Managing stress - Physical activity is a healthy outlet for managing stress. Getting regular (and enough) sleep helps limit stress and also supports long-term retention of knowledge.

Metacognition is thinking about one's own thinking and learning. A metacognitive learner knows when they are on the right track and when they are having difficulties.

- ❑ Explain what you're learning to yourself.
- ❑ When you get stuck: Ask for help. Start over. Keep working at it by trying to learn it a different way.
- ❑ Ask yourself questions: Did I already know that? How would I explain that to someone else? Does it conflict with what I thought I knew or thought I could do? With what parts of this do I need help or more practice?

Learning from a Distance

- ❑ Reaching out for help - You are not alone in this journey and should reach out to other members of your course and instructors when you have questions.
- ❑ Learn so that you can teach what you're learning to someone else.[1]
- ❑ Recognize that you can improve your learning by changing what you do.
- ❑ Stay positive. Own it.
- ❑ Don't just study to pass a test; strive to learn at a deeper level to gain expertise.[1] Remembering → Understanding → Using (applying, analyzing, creating)

Many aspects of learning, including strategy and effort, are under your control. Learning is not something done to you by a teacher. It is a process in your brain of adding and changing existing knowledge. Learning only happens if you actively participate in the learning process. Hard work and active engagement lead to deeper learning.

[1] Yancy & McGuire (2018)

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