Developing Transferrable Knowledge Using the Methodology for Generalizing Knowledge

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Abstract

The Methodology for Generalizing Knowledge (MGK) is introduced as a guide for the process of turning knowledge into working expertise that can be fluidly transferred to novel future contexts. Generalizing is a process that requires analyzing how knowledge is applied across increasingly diverse contexts, revealing cues which signal when and why application of that knowledge is needed, along with underlying principles required to successfully apply the knowledge. This study takes an educational design research approach incorporating participatory action research and educational design research to connect prior research on metacognitive processes in learning, problem solving, and levels of learning to produce the MGK. The results advance understanding of the generalizing process, provide a model of the process illustrated with a simple example, and connect it to the processes of learning, problem-solving, and transfer of knowledge.

Introduction

A critical ingredient in effective performance of learning and problem-solving is the ability to transfer existing knowledge to new contexts. For transfer to occur, there must be available generalized knowledge which can be applied to new contexts as working expertise. It is the process of generalizing knowledge that enables fluid transfer of that knowledge for new learning and for application to novel problem-solving situations. Unfortunately, systematically helping learners develop the skill of generalizing remains an elusive challenge. Students often struggle with tasks asking them to use what they have just learned when the context of using that knowledge shifts even slightly (Hammer et al, 2005; Rebello et al., 2007; Woolridge & Weinstein, 2016). This frequent failure to successfully leverage existing knowledge that would be valuable in new contexts illustrates the important role generalizing plays within the learning process and how the skill of generalizing is critical to problem solving.

In their discussion of knowledge transfer, Bransford and Schwartz (1999) note that "learning with understanding is important for enhancing performance on subsequent transfer tasks," and that "without attention to the degree of original learning, people can erroneously conclude that potentially helpful educational programs are ineffective." Their reference to the degree of learning—and learning with understanding—reflects how knowledge must be generalized to operate across contexts during transfer. Further, Leise, Beyerlein, and Apple (2007) illustrate with the Learning Process Methodology (LPM) how sufficient construction of knowledge (i.e., generalized knowledge) is needed to prepare for problem solving. With respect to learning, the LPM utilizes models to guide the learner in applying the same knowledge in multiple contexts and asks the learner to conduct critical thinking exercises which illuminate cues and underlying principles supporting use of the knowledge in a generalized way.

The process of generalizing is also fundamentally connected to problem solving. One can imagine the difficulty a person might have when solving problems, if they lacked the necessary working expertise to identify key issues, collect relevant information, identify assumptions, and generate solutions. The Problem Solving Methodology (Myrvaagnes et al., 1999) explicitly addresses each of these skills. These ideas are echoed by Chase, Malkiewich, and Kumar as they discuss how "noticing" impacts transfer situations in engineering (2019), or what Perkins (2008) deems "proactive knowledge" accessible even in low cue environments. Myrvaagnes notes that new knowledge generated from the problem-solving process should be generalized for future use. Generalized knowledge is thus a critical connection linking the learning and problem-solving processes. Apple, Ellis, and Hintze explain it this way:

> The relationship between these two processes is more than close; they are actually interdependent … learning is the process of constructing knowledge **in order to solve given problems**. Learning produces transferable knowledge (acquisition process) while problem solving is the sophisticated usage of this knowledge in a specific situation (application process) (2016b)

These connections between generalizing, the learning process, and problem solving have produced a need to clarify what the *application* level of knowledge looks like, especially at its highest level. Bobrowski (2007) states that in order to problem-solve the learner must have

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> …the skill to apply and transfer the particular item of knowledge to different situations and contexts, … recognize new contexts and situations to skillfully make use of this knowledge, … and (have) taken the time to generalize the knowledge to determine ways to apply it, testing boundaries and linkages to other information.

Nygren (2007b) calls this level of knowledge "transferable knowledge" or simply generalized knowledge. A learner with generalized knowledge is able to efficiently produce quality results based on working principles and even propose criteria to define quality as they tackle problems others can't (2007a). Appendix A expands on Nygren's work to provide details about what this knowledge looks like across the five different forms of knowledge (Quarless, 2007).

We introduce the Methodology for Generalizing Knowledge (MGK), as an explicit tool to help learners meet the challenge of elevating knowledge to the level of working expertise. Table 1 shows the four stages of the methodology with the steps for each.

As shown in Table 1, there are four distinct stages within the MGK:

1) **Validate readiness** to generalize by ensuring meaningful understanding exists (Step 1)
2) **Apply the knowledge** in different contexts (Steps 2 – 5)
3) **Analyze each application** to find cues and underlying principles (Steps 6 and 7)
4) **Build working expertise** by solidifying newly generalize knowledge (Steps 8 and 9)

The methodology begins in Stage 1 with Step 1's self-check on understanding of the knowledge one hopes to generalize. This step, similar to activating prior knowledge (Pressley et al., 1992), is intended to disabuse the learner of any assumption they may hold about already knowing. The step is essential for understanding what the knowledge represents; without it, the learner risks wasting effort by attempting to apply knowledge where actual understanding is limited. The best check for Step 1 is learners ensuring

Table 1 Simplified Methodology for Generalizing Knowledge

Stage/Step	Short Description
STAGE 1 — Validate readiness	
Step 1: Confirm knowing	Test understanding to ensure you can explain and respond usefully to questions
STAGE 2 — Apply the knowledge	
Step 2: Familiar context	Apply the knowledge in a very familiar context to explore how it works
Step 3: Similar context	Apply the knowledge in a slightly different context to explore how to transfer it
Step 4: Different context	Use the knowledge in a more challenging and different context
Step 5: Unfamiliar context	Use the knowledge in a personally challenging and difficult context with which you are not familiar
STAGE 3 — Analyze each application	
Step 6: Cues	For each context, inventory reasons why the knowledge was useful
Step 7: Underlying principles	For each context, extract the rules or approaches to using the knowledge that act as tips for successful application of the knowledge
STAGE 4 — Build working expertise	
Step 8: Make the generalization	Describe an integrated cue statement for why this knowledge can produce significant value given a set of conditions and a sequenced set of common underlying principles for producing that value
Step 9: Confirm working expertise	Reapply the knowledge through the prior contexts to validate increased capability in producing value with the knowledge

their understanding by teaching others and answering their questions.

Stage 2 comprises Steps 2 through 5 which progress through four applications of the knowledge in increasingly less familiar and more challenging contexts. Ideally, these four steps sequence both the difficulty of the context used, as well as the number of principles applied. As such, this stage applies the concept of *scaffolding*, as described by Hammond and Gibbons (2005); difficulty increases as the context moves from familiar to similar, to different, and finally to unfamiliar. In addition, scaffolding the complexity of application of the knowledge requires more of the component elements, or principles, of that knowledge with each new context. This will ensure not only a comprehensive collection of reasons why the knowledge becomes useful but also significantly widens the application of the knowledge by the time all four applications are complete.

Stage 3 (Steps 6 and 7) is where application of knowledge is analyzed in each context for cues as to reasons why the knowledge was useful and inventorying underlying principles governing the use of knowledge in each context. These steps are precursors to developing what Ambrose et al. (2010) summarize as mastery of the knowledge, where learners integrate needed skills to apply the knowledge and discover when and where to apply those skills. The process in Step 6 involves significant metacognitive thinking about what conditions make application of knowledge valuable as the learner explores similarities and differences among specific reasons the application of the knowledge was valuable in the four contexts. This results in a set of cues that indicate potential value for the knowledge in future situations and the conditions necessary for this value to be produced. After inventorying these cues, in Step 7 the learner works to identify the underlying principles that describe how the knowledge was effectively applied in all four contexts. The authors note from personal experience that learners are frequently frustrated with first attempts at completing these two steps. Not only is the knowledge they are developing just emerging at the application level, but many have not explicitly practiced the skills of identifying cues or underlying principles. Therefore, when initially using the MGK, it may be helpful to use existing prior learning that one would like to elevate which already spans multiple applications so one can focus on developing skill in applying Steps 6 and 7.

Finally, in Stage 4, working expertise is constructed through Steps 8 and 9. The term *working expertise* is taken from Nygren (2007b) and is consistent with the description by Ericcson (2005) in their commentary on how advances in expertise research apply to educational settings. In Step 8, the learner makes the generalization by cross-referencing the cues and principles across each context to determine the value that knowledge produced within each context. They also predict new contexts for when and where the knowledge might be useful in order to produce an integrated cue statement that matches the reason it is valuable with appropriate conditions. Another purpose of Step 8 is to compare the principles used in each context to identify which principles apply universally and which apply in only some contexts. Finally, in Step 9, validation of the resulting generalization is accomplished by reapplying this elevated knowledge, in its generalized form, to each context to test that this generalized knowledge is adding significant value to each context.

Literature Review

Generalizing is not the same as transferring, with respect to knowledge. Rather, generalizing is a learning skill that develops working expertise to a level enabling transfer of knowledge, when needed, to novel contexts. More specifically, the process of generalizing produces cues and underlying principles to link knowledge across multiple diverse contexts in order to facilitate problem solving. In short, *generalizing* is a deliberate learning process elevating one's level of knowledge for use in problem solving, while *transfer* is the ability to apply knowledge in a new context.

Metacognition, as defined in Schraw and Moshman's (1995) influential paper, may be usefully separated into "metacognitive regulation of thinking and learning" and "metacognitive knowledge." Subtypes of metacognitive knowledge are declarative knowledge about things, procedural knowledge about how to do things, and conditional knowledge about why and when things may be used. *A metacognitive theory* is knowledge that integrates a specific collection of declarative, procedural, and conditional metacognitive knowledge. Generalizing is an example of a metacognitive process (of thinking about thinking) that produces a specific metacognitive theory which guides the transfer of knowledge for a particular set of problem areas.

Connecting generalizing and other methodologies as generalizations of metacognitive processes (Apple et al., 2016a) allows the results being developed in metacognition to apply to Process Education as well. Moshman, in an update to Schraw and Moshman's 1995 paper, noted that many educational institutions "fall short of helping students (a) to understand the structure of theories, and (b) to use theories to systematize self-knowledge and apply that knowledge to self-regulation" (2018). Because Process Education methodologies, including MGK, are metacognitive procedural knowledge designed to support students' creation of knowledge, they hold the potential to help education institutions adopt a Process Education approach, especially in fields reliant on problem solving and transfer of knowledge.

This description of generalization and transfer is consistent with prior research, in particular the large body of work on transfer as summarized by Lobato (2006). Nevertheless, the terms *generalizing* and *transfer* are often used interchangeably by practitioners (e.g., De Lay, 2016; ErinoakKids Centre for Treatment and Development, 2020). Therefore, we define *generalizing* and *transfer* as follows:

- *Generalizing* (preparing to use knowledge in new contexts) is the systematic production of robust understanding (working expertise) by analysis of knowledge use in multiple contexts, enabling transfer of that knowledge to novel future contexts
- *Transfer* (using the knowledge in a new context) is the application of prior knowledge or skills in a new context

We also define two more terms important for the discussion of generalizing, consistent with metacognitive conditional knowledge:

- *Cues* (triggers signaling that transfer is possible) are indicators, based on stimuli or prompts, that signal the need to apply certain knowledge within a learning context or problem-solving situation
- *Underlying principles* (requirements for applying the knowledge in a context) are rules or guidelines indicating how certain knowledge is applied within a learning context or problem-solving situation

The work by Sweller (2016) on cognitive capacity, together with Tricot and Sweller (2014) on why teaching general approaches to problem solving often fail, explains why the metacognitive process, as presented in the MGK, serves as a bridge to problem solving. Tricot and Sweller relate that learners without long-term memories of using relevant problem-solving knowledge are limited by working memory and are thus unable to deal with complexity. That is why initially learning from a worked example is effective: it allows learners to limit complexity by focusing on what is present in the example. As problem-solving experience grows, learner knowledge moves from short- to long-term memory, removing limits on how much working memory can be activated to solve a problem. This provides a mechanism for expertise, where substantial case knowledge is available to the expert without any constraint in use due to short-term memory limitations. With sufficient memory and working expertise developed from generalizing with the MGK, a learner can both apply knowledge and reason about that knowledge to perform Piaget's reflective abstraction/generalizing. Schraw (1998) shows that metacognitive knowledge is multi-dimensional, teachable, and applies generally across domains, so metacognitive theories such as MGK and its results, by specifying incremental, general steps, guide advanced problem-solving and may even accelerate it by limiting the complexity required. Schraw also describes the difficulty of researching metacognition due to opacity. The MGK and other methodologies that produce explicit descriptions of metacognitive theories support a window into the details of learning, reasoning, generalizing, transfer, and problem-solving amenable to qualitative research methods.

To further illustrate our definitions of *generalizing* and *transfer*, we note a case study from history used to illustrate the concept of generalizing in *How Students Learn: History, Mathematics, and Science in the Classroom* (National Research Council, 2005). There, the authors indicate that generalizing seems to occur when searching for principles extant in similar contexts. In our model, we propose that extracting "underlying principles" to explain a concept's use in different contexts is indeed critical to the skill of generalizing. Similarly, the seminal text *How People Learn* (National Research Council, 2000) devotes an entire chapter to learning and transfer, explaining that context is important in learning for transfer, but knowledge that is too contextualized hinders transfer. Therefore, we conclude that multiple contexts for the same knowledge are needed for generalizing, and we propose the same knowledge applied to increasingly *different* contexts is critical to generalizing. Finally, Herr (2007) describes "flexible representation of knowledge" as a major factor influencing transfer and includes the term *generalizing* to describe how transfer occurs to produce new learning or to solve problems. Although Herr does not clarify whether generalizing represents flexible representation of knowledge, transfer, or both, the overall conceptualization of generalizing enabling transfer is consistent with our definitions.

Generalizing makes use of the more fundamental process of applying knowledge. Atkinson and Shiffrin developed a cognitive framework commonly referred to as the *modal model* that combines the notion of short and long-term memories along with control processes that operate on them (1968). They contributed much to understanding *rehearsal* and *retrieval* control processes that first create long-term knowledge from short-term knowledge through rehearsal, and second make long-term knowledge available through retrieval. A later addition to the modal model, called SAM (search of associated memory), was developed by Raaijmakers and Shiffrin, and contributed the importance of context in retrieval as prompts and contextual cues (1980, 1981). *Recognition*, as "activating knowledge held in long-term memory that applies in a situation" extended the modal model further (Juola et al., 1971; Atkinson et al., 1974; Atkinson & Juola, 1973, 1974). Subsequent research clarified how retrieval works probabilistically across multiple, similar target memories. Learners reinforce memories through rehearsal and hence increase the probability of the memories being recalled when needed.

Rehearsal helps learners reinforce memories and contextual cues when they use a formal process and explicit representation of knowledge to be learned. Working with children as language learners, Karmiloff-Smith developed the theory of Representational Redescription to describe four progressive levels of internal knowledge representation during learning (1994). The levels are, from highest to lowest,

- I, implicit knowledge, which is automatically applied
- E1, explicit knowledge, which is unconscious and opaque to language
- E2, consciously explicit knowledge but opaque to language
- E3, consciously explicit knowledge describable using language

The theory is useful in explaining how implicit knowledge transitions to explicit, shareable knowledge. Beaudoin uses Karmiloff-Smith's theory to explain how older children and adults transform objective, externally represented knowledge to explicitly represented, internal knowledge, E3, and progress through levels E2, E1, and I through deliberate practice (2014). In the same work, Beaudoin relates them to Piaget's concepts of assimilation, accommodation, and reflective abstraction.

Assimilation, as developed by Piaget and described by Beaudoin, relates concepts derived from information in a knowledge source to concepts already known by the learner. When a learner is presented with new concepts that do not fit with the old, they may, through careful reasoning, accommodate the new concepts by using learning skills to restructure their knowledge. The highest level, *reflective abstraction*, is a deliberate process of reviewing what one knows to build generalizations. The MGK described in this paper is an explicit representation of knowledge that relies on enhancing retrieval of internal concepts to guide the generalization process. Learners also construct methodologies (metacognitive theories) to represent problem-solving approaches. (For more on methodologies, see Smith & Apple, 2007.)

Finally, Fyfe et al. (2014) reviewed *concreteness fading*, an approach used primarily in mathematics and science consisting of a three-step process led by a facilitator and moving from concrete to abstract representation "guiding learners to strip away extraneous concrete properties and distill the generic, generalizable properties." It is our contention that a learner, with practice, can identify and use just four contexts to produce generalized transferrable knowledge.

Methods

The overarching goal of the research related to the Methodology of Generalizing Knowledge is to develop, test, implement, improve, and scale up a methodology that learners can, with practice and coaching, use to generalize knowledge in support of transferring their learning to new problems and a methodology that instructors may effectively teach.

AR/PAR

The beginnings of the MGK can be traced to an Advanced Teaching Institute (ATI) held at Edgewood College, June 10-14, 2000. The overview and stated outcomes of that Advanced Teaching Institute (Apple et al., 2000) firmly situate the initial work leading to the MGK within the tradition of Participatory Action Research (PAR).

Action research (AR), as described by Reason et al. (2001) and Denscombe (2014) is concerned with the real-world, is designed to develop and test change strategies, uses a cyclical feedback process, and involves practitioners as participants and sources of knowledge. James et al. built upon that, naming a form of AR "Participatory Action Research" (PAR) because it goes further than AR, giving full status to the participants instead of simply involving them.

The outcomes of the Advanced Teaching Institute include the statements, "The themes to be pursued at the event are determined by the needs and priorities of the participants" and "Educational research and generating new knowledge are priorities" (Apple et al., 2000). Further, an overview describing the ATI highlights that it differs from a Teaching Institute in that "there will be a greater orientation toward research (especially action research) and generating new knowledge" (Apple et al., 2000). This centering of the research conducted during an ATI, as based on the needs and priorities of the participants, allows us to categorize the products of that institute as the result of PAR, regardless of how incomplete that work might be. In the case of the MGK, its very beginnings can be traced to ATI learning activity #14, Working on the improvement of the quality of Assessment, on June 11, 2000. The effort was focused on raising insights from level 1 of Bloom's Taxonomy (knowledge) to Level 3 (application). The journal from this event attempts to record "Effort to raise this (insights in an assessment) to Level 3 by each group." It then offers a series of level 1 insights. The final sentence recorded in that final activity of the day is, “Perhaps a methodology for getting from Level 1 to Level 3 may be helpful” (Apple et al., 2000).

Dan Apple recalls

> That evening (June 11, 2000), I created the Methodology for Elevating Knowledge from Level 1 to Level 3. The next day (June 12, 2000), we shared this methodology and started working with it. We didn’t have an activity or anything, but I just used the learning challenge people were struggling with which was the relationship between cooperative and collaborative learning [to explore the new methodology] (D. Apple, personal communication, April 8, 2023).

The first iteration of the Methodology for Elevating Knowledge appears as part of the results of Activity #19, Methodology for Quality Assessment, in the ATI Journal; Steps 4 through 9 form the basis of the nascent MGK (Apple et al., 2000):

1. With the framework [of understanding] in place, test the conditions of the structure (e.g. the validity of the assumptions, the logic, value or benefits, what else….) (level 2)
2. To enrich the knowledge, find a context you are familiar with and, transfer and apply the knowledge to that context. (low level 3)
3. Transfer and apply the knowledge to another context that is similar. (low level 3)
4. Make a transfer and apply the knowledge to a context that is far away from the original context. (level 3)
5. Pick a totally unfamiliar context (e.g., different culture, discipline) and transfer and apply the knowledge; play role of consultant. (level 3)
6. Make a generalization (level 3)

One of the event participants, Kip Nygren, shared the observation that critical thinking questions are a tool for exploring the transfers at each level. Of note, Kip would go on to write the *Faculty Guidebook* module on Elevating Knowledge from Level 1 to Level 3 (Nygren, K., 2007b). This represented not only a further iteration of stepwise generalizing within PE research, but continuity of participation.

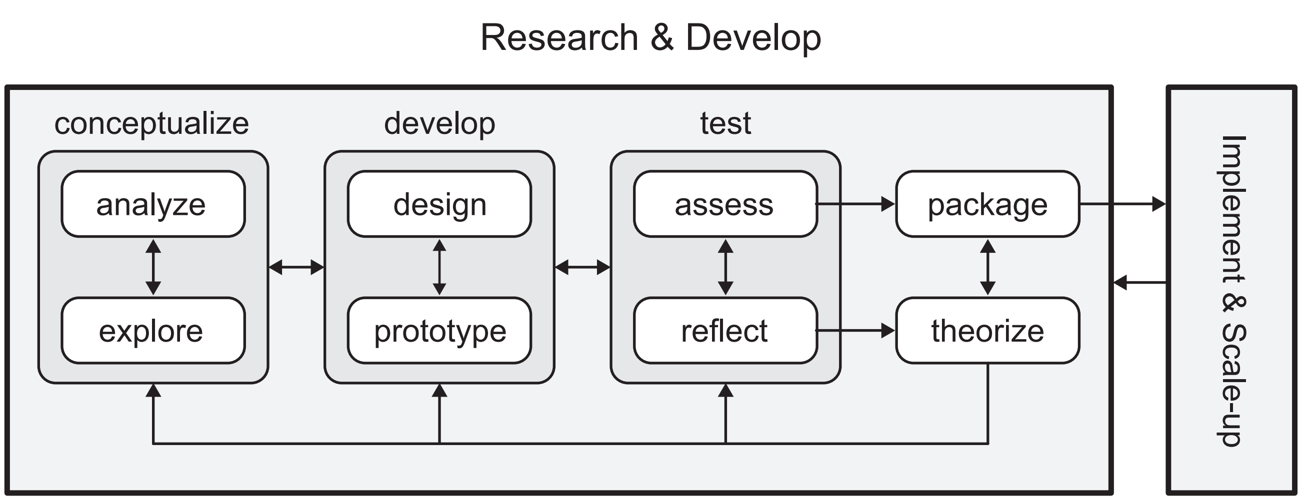
Educational Design Research (EDR)

While PAR describes the context and stakeholders of the inception and initial research on MGK, it does less to capture the iterative nature of that work over the years since. To appreciate that process and its contribution to the current MGK, we rely on Educational Design Research.

As described by McKenney & Reeves (2012), EDR provides a strategic framework that progresses iteratively from concept to implementation to produce a quality educational design that can scale to broad practice. Figure 1 depicts this framework which aims to give structure to the research process using a participatory, real-world approach involving teachers and students (broadly defined) to ensure resulting implementations are teachable and effective. As experience is gained, researchers develop theoretical explanations.

EDR is a way to appreciate the structure of long-term research to coordinate many smaller research projects. The structure can also guide the development of a design iteratively across the conceptualize, develop, test, package, theorize, and implement/scale up phases. With EDR, a researcher applies methods, involves educators in generating solutions, and engages learners in learning and applying the methods. Researchers also induce practical, effective solutions from the practice and reflection of the participants that are then iteratively tested and refined to improve the results. In the case of the MGK, EDR was not used as

Figure 1 The flexible research framework of EDR. Adapted from McKenny & Reeves (2012)



a project plan for how to proceed, but rather provides a schema or lens that allows for appreciation of the iterative and improvement-focused "conceptualize-develop-test" process that took place with the MGK.

PAR within EDR

The Participatory Action Research approach continued over subsequent years in the contexts of various faculty development institutes, work on learning to learn curricula, and no fewer than three Process Education Conferences. Participants in each of these contexts shared input that was analyzed and then integrated into the evolving MGK. Each iterative improvement consisted of a set of processes analogous to a PAR loop as situated within the larger project-type structure of EDR (Figure 2).

The PAR-within-EDR cycle may start anywhere, but typically begins by studying the practice as it is currently performed, collecting qualitative and/or quantitative data, and proceeding to Steps 2 and 3. The cycle ends when assessment and reflection determines whether theorizing or packaging could be done. Unproductive cycles either continue iterative improvement or determine the current path will not yield quality results.

After the authors began concerted work on generalizing, we packaged an updated version of the MGK. In terms of Figure 2, this package exited the general PAR loop to be introduced as a paper submitted to support a workshop on generalizing knowledge at the 2017 PE Conference (Utschig, 2017). There, another PAR cycle occurred with groups of faculty working through the methodology, using think-aloud approaches and documenting their efforts using the methodology for a variety of different types of knowledge. This work led to another version (revision) of the methodology and an extended, revised paper was presented at the 2018 PE conference, where the methodology was shared in a research session and feedback on the paper was solicited and collected (Utschig, 2018). From that input, the paper was revised again, and another PAR context was created in the form of a workshop session delivered at the 2019 conference where participants were introduced to the content of the paper and the MGK within it, then working in groups to utilize the MGK as part of the workshop (Utschig, 2019). That led to additional revisions and brought us to the cycle of feedback immediately preceding publication of this article. This sequence of conference workshops represents several PAR-type cycles contributing to the larger EDR-type cycle. The result, after a variety of refined and packaged versions of this theoretical model, is the Methodology for Generalizing Knowledge.

While this research completes the foundational aspects of the overarching goal to develop, test, implement, improve, and scale up a user-friendly and useful methodology, much remains to be done with respect to the EDR iterations of implementation, improvement, and scaling up. Those aspects are beyond the scope of this paper. Nonetheless, we offer ideas for future research along these lines in the conclusion.

Results

Table 3 offers a detailed explanation of the content introduced in Table 1 and the supporting descriptions of the four stages. We explain what needs to occur within each step to achieve stronger results from using the MGK presented in Table 1. The explanations offered here for each step are intentionally written using second person language speaking directly to the learner.

Figure 2 The iterative process of PAR embedded in EDR. Adapted from Denscombe (2014); James et al. (2008), & McKenny & Reeves (2012)

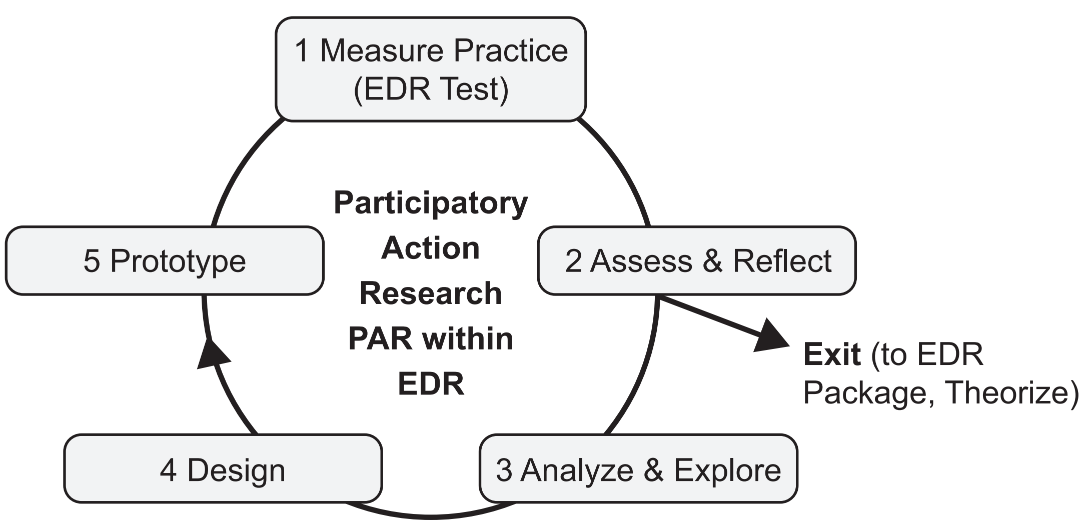


Table 3 Methodology for Generalizing Knowledge

Stage/Step	Description
STAGE 1 – Validate readiness	
Step 1: Confirm Knowing	**Test the quality of understanding.** Check if you can truly articulate what this knowledge means before applying it. Can you explain the knowledge to someone else? Is your understanding strong enough to answer their questions? Have any potential misconceptions emerged, or have any limitations been discovered about the meaning of this knowledge?
STAGE 2 – Apply the knowledge	
Step 2: Familiar context	**Explore and enrich fundamental understanding.** Choose a context so familiar that you can use the situation to clarify your understanding and test validity by seeing if it works the way you understand that it should. Reflect on any new learning, note cues as to why the knowledge was useful in this context, and note any principles or rules used to apply the knowledge.
Step 3: Similar context	**Contextualize the knowledge.** Pick another context that is similar, but not as familiar, to investigate how to move this knowledge effectively to this new context (i.e., transfer). Again, reflect on your learning to identify additional cues showing why the knowledge was useful for this context and rules (principles) required for how to transfer the knowledge.
Step 4: Different context	**Choose a context that has key differences from the previous contexts.** Select these different characteristics to provide a challenge in transferring the knowledge. Reflect on new learning to identify other cues showing why the knowledge was useful to this context and additional rules (principles) required for effective transfer.
Step 5: Unfamiliar context	**Transfer knowledge to a distant context.** Thinking like a consultant, take a personal/professional situation and determine how one could make use of this knowledge to produce value in this situation. Choose the most complex scenario you can imagine for applying this knowledge. Include all possible issues that might arise in the situation. As always, identify the additional reasons why one would use this knowledge (cues) and rules for how it was effective (principles).
STAGE 3 – Analyze each application	
Step 6: Cues	**Inventory all reasons and associated conditions for why the knowledge was useful.** Review and list unique reasons why and associated conditions from each of the four contexts to explain why the knowledge produced important value. The goal is to understand and be able to explain the conditions for any situation that make the knowledge capable of producing value when it is applied.
Step 7: Underlying principles	**Inventory principles (rules) used to apply the knowledge.** For each of the four contexts, list the principles that must be followed for the knowledge to produce the intended outcome. What had to be followed to skillfully apply the knowledge and produce value in each context? How would you articulate this rule as a tip for someone else to help them learn to successfully apply the knowledge?
STAGE 4 – Build working expertise	
Step 8: Make the generalization	**Generalize understanding.** Through reflective thinking & writing: 1) describe similarities and differences between the why the knowledge was valuable and the conditions (cues) which might trigger additional inquiry in order to expand your overall understanding of why and when to use this knowledge; 2) identify the common underlying principles used in applying the knowledge across all contexts and sequence them; 3) identify value produced by applying this knowledge to each context, 4) predict new contexts where value can also be produced.
Step 9: Confirm working expertise	**Reapply the knowledge, now using it as working expertise.** (This is your expanded why, knowledge of the conditions, and sequenced list of principles). Rework each of the four contexts to see how much capability you have in producing value with this generalized knowledge. The greater the value added, the stronger the generalization.

Table 4 Simple Example of Using the MGK: Sharpening a Cutting Tool

Stage/Step	Description
STAGE 1 – Validate readiness	
Step 1: Confirm Knowing	Making a cutting or piercing tool sharp with a designed sharpening resource enhances the ability to cut or penetrate an object more effectively, quickly, and with greater precision
STAGE 2 – Apply the knowledge	
Step 2: Familiar context	**Sharpening a smooth-edged kitchen knife blade** Using a whetstone (be sure to soak the stone for 10 minutes before you use it), move the knife straight down an imaginary center line, pulling the handle away from the stone as you go to hone both the straight and curved part of the edge. Repeat this motion several times to ensure the edge of the knife is sharp, then repeat on the other side of the knife edge. (https://www.thespruceeats.com/guide-to-sharpening-a-knife-4081187)
Step 3: Similar context	**Sharpening scissors** Fold a sheet of 150 grit aluminum-oxide sandpaper in half so the abrasive surfaces are visible. Use the scissors to cut the sandpaper into narrow strips. Each cut of a strip will sharpen each blade of the scissors a little bit.(https://www.wikihow.com/Sharpen-Scissors)
Step 4: Different context	**Sharpening a lawnmower blade** Remove the blade from the lawnmower. Clamp the blade in a vice at an angle with one of the cutting edges facing up. Notice that the cutting edges at each end of the blade are only 3 or 4 inches long and are only on one side of the blade (the other side is flat). Using a drill-powered blade sharpener, slowly move the stone back and forth along the cutting edge with moderate pressure. Repeat the process on the other end of the lawnmower blade, removing a similar amount of material as you sharpen. Check to make sure the blade remains balanced by placing the blades center hole over a nail and continue sharpening on the heavy side if needed. (https://www.thetoolyard.com/2018/12/sharpen-mower-blade.html)
Step 5: Unfamiliar context	**Sharpening a serrated knife blade** Here you will only want to sharpen the beveled side of the knife. Never sharpen the wrong side of the knife. It is best to put the knife in a vice. Using a sharpening rod, carefully sharpen each valley or gullet on the serrated edge. On most serrated knives, the gullets are all the same, but on larger knives they may be of different sizes, and you will have to use different size sharpening rods. (https://imarku.net/blogs/news/how-to-sharpen-serrated-knives)
STAGE 3 – Analyze each application	
Step 6: Cues	1. Cutting edge cannot penetrate the current material. 2. Cutting damages the material, causing wastage. 3. Cutting doesn't match needs of the situation. 4. The cutting edge is dull. 5. Cutting precision is not acceptable. 6. Productivity is significantly reduced. 7. An instrument exists to sharpen this type of cutting tool.
Step 7: Underlying principles	1. Pick the appropriate sharpening resource designed for the cutting edge. 2. Apply the sharpening resource as designed. 3. Be economical in use of the sharpening resource. 4. Move either the cutting tool or the sharpening device but not both. 5. Flip the cutting edge to do both sides of the edge. 6. Ready the edge that will be sharpened. 7. Fix one of the objects so that it can't be moved. 8. Be consistent in applying the sharpening process (i.e., apply equally for balance by repeating without variation).

Stage/Step	Description
Step 7: Underlying principles (con't)	9. Validate the cutting tool is still in balance. 10. Never sharpen the other side of a single-sided blade. 11. At times, small improvisation will be necessary without violating design. 12. Remove a minimal amount of edge surface to reach level of sharpness. 13. When cutting edge's width is too short, remove some of the fatter part of the blade surface (the shoulder) to widen the edge. 14. Sharpen until the appropriate cutting angle is achieved across the entire blade length. 15. Repeat the process to get the degree of sharpness desired. 16. Avoid removing more material than is needed to extend tool life and maintain its strength. 17. Test frequently to get closer to desired sharpness without going beyond.
STAGE 4 – Build working expertise	
Step 8: Make the generalization	**Why** – when something's sharpness doesn't meet current need in effectiveness, productivity, quality, or precision in cut, sharpening will return the function of the cutting edge so it meets the desired specifications. **Conditions** – When the cutting edge cannot penetrate current material, damages the material (causes wastage), doesn't fulfill the need of the situation, is dull, the precision is not acceptable, or productivity has been reduced, and an instrument exists to sharpen this type of cutting tool. An additional condition is that you can carry out the process safely (otherwise, bring the cutting tool to an expert). **Basic Principles** – There are a set of things to do to sharpen a cutting edge effectively: 1. Pick the appropriate sharpening resource (the one designed for the cutting edge). 2. Apply the sharpening resource as it was designed. 3. Be economical in use of the sharpening resource. 4. Move either the cutting tool or the sharpening device but not both. 5. Be consistent in applying the sharpening process (i.e., apply equally for balance by repeating without variation until the appropriate cutting angle is achieved). 6. Repeat process to get the degree of sharpness desired. 7. Sharpen until the appropriate cutting angle is achieved across the entire blade length. 8. Test frequently to get closer to desired sharpness without going beyond to extend tool life and maintain its integrity by removing a minimal amount of edge surface. **Conditional Principles** 1. Ready the edge that will be sharpened (especially when cutting edge is hard to access). 2. When cutting edge's width is too short, remove some of the fatter part of the blade surface (the shoulder) to widen the edge. 3. Never sharpen the other side of a single-sided blade (single-sided cutting edge). 4. Validate the cutting tool is still in balance (when balance in cutting edge is required). 5. Flip the cutting edge to do both sides of the edge (only with a two-sided cutting edge). 6. Fix one of the objects so that it can't be moved (when recommended for applying the process consistently). 7. At times, small improvisation will be necessary without violating design.
Step 9: Confirm working expertise	With this expanded why, conditions, and principles, sharpen the knife, scissors, lawn mower, and serrated knife once again to see if you can sharpen more quickly, safely, and with greater precision, resulting in minimal wastage and cutting-edge meeting intended specifications. We then imagine where and how another sharpening surface could be transferred to a different cutting object such as a shredder, a hedge trimmer, or a chisel.

In Table 4, we offer an illustrative example for the use of the MGK. We have chosen to use an area of knowledge for which nearly every reader should feel a significant familiarity: sharpening a cutting tool such as a knife. By choosing this topic, we expect the reader should be able to follow the steps of the MGK without having to construct any additional knowledge to successfully enter Stage 1 of the methodology.

While exploring the following example of generalizing, keep in mind the following perspectives on this knowledge:

- What (sharpening is a process to make an instrument cut better)
- Why (making the instrument more effective, efficient, and precise in use)
- How (here a sequenced set of eight universal and seven conditional principles or rules that when used will produce sharp instruments)
- When and where (conditions providing cues something's sharpness doesn't meet current need in effectiveness, productivity, quality, or precision)

Discussion

Generalizing focuses on building capability to use particular knowledge effectively and efficiently across any context, as opposed to simply increasing understanding. Thus, the nine step MGK articulates how to use knowledge that is meaningful (high level 2) and from this construct generalized, transferable knowledge (low level 4). The methodology was designed to support five perspectives which cue the reader where they can use the MGK.

1. Life-long learners can use the MGK to strengthen learning performance through generalizing. Everyone can do this.
2. Learning facilitators can use it to mentor learners more effectively in generalizing, especially when prerequisite knowledge is not transferable.
3. Designers of learning activities can produce learning activities that incorporate all nine steps of the generalizing methodology.
4. Researchers can guide qualitative research by following many of the steps of the MGK and can make explicit the metacognition involved in key learning and performance tasks to support additional research.
5. Problem solvers can trigger the use of this methodology when their ability to transfer knowledge is not satisfactory and the knowledge is critical to an effective solution.

In each of these situations, we need working expertise and without it, the applied learning doesn't meet the needs of the situation. The conditions in each of these five areas that make generalizing valuable are when

1. Knowing is not enough (level 2 does not meet level 4 need)
2. Experience of use across several contexts will help to address the given requirements more effectively
3. Current ability to transfer the knowledge is limited without someone prompting its use
4. Current generalizing process and supporting learning skills are not strong
5. One is not up to the challenge of designing or using world-class learning experiences
6. One wants to elevate the value of insights when using reflection and self-assessment (Leise et al., 2022)

The methods and analysis here produced an integrated why and six conditions when using one's knowledge in sharpening that will produce significant value.

The following represents an inventory of the benefits from using the MGK with the principles in situations when these cues exist. It is our hope that this list helps others to generate insights about the value of incorporating generalizing into the learning process for any context.

1. Knowledge that will support expected future learning: When having learned something potentially intriguing for later use, applying the MGK will greatly enhance ability for unprompted use of that knowledge when one can see potential for expanded value. Cross-context usage of knowledge will create additional meaningful value.
2. One is having difficulty in using existing knowledge: Each context provides a potential opportunity to generate new and refine existing principles.
3. To validate the value of the knowledge: Contexts produce means to document value by demonstrating that the generalized knowledge is worthwhile.
4. Prerequisite knowledge is deficient: Moving prerequisite knowledge from familiar to unfamiliar contexts enables re-use of learning from prior efforts. The process can clarify all areas where understanding is fuzzy.
5. Solving problems: Knowledge is needed when entering a new, previously unexpected context. If a problem becomes complex quickly, then generalized knowledge of content related to the context needs to be developed first.
6. Spinning your wheels: When one isn't sure how to apply what they have learned, working through the MGK will greatly strengthen that ability. Intentionally exploring generalizing the knowledge may turn this

wasted energy into productive struggle and develop a willingness to take leaps in complexity with application of the knowledge.

7. Credibility in application of the knowledge is needed: The process should iteratively increase skillfulness in use of the knowledge.

We now turn to the principles (rules or truths) about generalizing that are needed to successfully apply the MGK. We identify five common underlying principles for applying generalizing, stating each principle and then describing the value the principle brings to any context where generalizing will be applied.

Principle 1 New generalized knowledge can only be built upon current generalized transferable knowledge. This requires the learner to effectively transfer prerequisite knowledge to the current learning challenge (otherwise the perceived knowledge construction will be "fragile").

Generalizing is a critical capability that can dramatically improve both learning and problem-solving performance. In contrast, fragile knowledge is produced by the "training model" of identifying specific skills and helping students to recognize and apply these skills to specific contexts using lots of practice. What is missing in the training model is learners understanding how and why they do what they do. Consequently, the ability to take these skills and apply them to new situations is deficient (lack of generalization). This essentially rules out effective and efficient problem solving.

Principle 2 The development of strong comprehension is a crucial stage in the learning process and is a prerequisite for being able to contextualize, generalize, and transfer knowledge.

This principle is embedded within Steps 1-10 of the LPM (Leise et al., 2007). When these steps have been effectively implemented, a learner is ready for the MGK. Nygren (2007a) illustrates readiness for generalizing knowledge within the table, Levels of Knowledge Across Knowledge Forms (see Appendix A), where such knowledge is characterized by the ability to: 1) synthesize with previous knowledge; 2) effectively communicate the knowledge to others; 3) internalize the knowledge; 4) clarify boundaries; 5) and explore possibilities for use.

Principle 3 Working expertise (generalized knowledge) is required for quality problem-solving performance.

Only recently have efforts by Process Educators focused on the need for students to develop the ability to generalize knowledge for transfer, bridging comprehension (level 2) to problem-solving expertise (level 4). For example, the five-year STEM UP program (Perkins, 2016) utilized a Learning to Learn Math Camp preceding the startup of the program to increase student learning performance in mathematics using *Foundations of Algebra* learning activities (Ellis et al., 2013). Pacific Crest also investigated having students use the Methodology for Elevating Knowledge (MEK) (Nygren, 2007b) in their recovery courses for university students trying to move off of probation or reenroll after dismissal. This practice introduces students to the concepts of generalizing and metacognition, including an assignment requiring elevation of knowledge using the resource *Learning to Learn: Becoming a Self-Grower* (Apple et al., 2013). These efforts produced major advancements in developing learner performance (Apple et al., 2016b).

Principle 4 The combination of Step 5 (Performance Criteria) and Step 13 (Self-Assessment/Self-Validation) of the LPM are used to test if knowledge has been generalized (a final meta-cognitive check).

With this principle, the learner distinguishes between thinking they know and knowing they know. This check is derived from three other methodologies: the Learning Process Methodology, the Problem Solving Methodology, and the Methodology for Elevating Knowledge from Level 1 to Level 3.

Principle 5 Knowledge cannot be transferred if the learner is unable to discern the contextual prompts in a situation because the knowledge will never be activated.

Nearly every faculty member has asked students, “Don't you remember doing this last week?” and heard students respond, "We’ve never seen this before!” The students do not recognize the need for the prerequisite knowledge in the current learning without the faculty dragging that knowledge out of them and filling in the gaps.

Conclusion

This paper offers new tools and perspectives to aid in understanding generalizing and what generalized transferable knowledge represents. In particular, the MGK describes the process required to produce generalized transferable knowledge and is connected to the different levels of knowledge produced during the generalization process. We have provided a detailed description of the MGK and an example of its application we believe is accessible to most readers because, in their life, they have likely implicitly completed Steps 1 and 2 of the MGK for the topic chosen.

The example provided in this paper is equivalent to performing Step 2 of the MGK on one’s way to generalizing the process of generalization. The authors recommend that the reader create their own similar, different, and unfamiliar learning situations where they can reuse the MGK in these three increasingly challenging contexts (Steps 3-5). The reader can, with the help of Steps 6 and 7, compare the cues and principles used in applying the MGK to those situations against those offered in the discussion section which, we argue, would bring the reader through the remaining steps of the MGK to develop a generalized knowledge of the generalizing process.

Additional research is needed to test the process of teaching and using the MGK. Future research questions include:

1. Can everyone learn to generalize knowledge?
2. Can every type of knowledge be generalized?
3. What are the key learning skills needed for generalizing?
4. Can the MGK be applied across different forms of knowledge in different disciplinary contexts to produce generalized knowledge? For example:
    a. Familiar: concept (e.g., adding mixed numbers in mathematics) as an easy way to start generalizing
    b. Similar: process (e.g., determining boiling point in a laboratory setting)
    c. Different: tool (e.g., citation software for writing)
    d. Unfamiliar: contextual knowledge or way of being (e.g., civil war or a growth mindset from a humanities and social science perspective)
5. What added value might be produced when using the MGK in learning communities and cooperative learning contexts?
6. Can we build a performance measure for generalizing?
7. Does assessing the use of the MGK itself contribute to the quality of generalized knowledge achieved, or does it simply increase capability to generalize for the future?
8. What is the impact of increasing the complexity of application (building principles) versus familiarizing oneself with situations for application (building cues) as learners work through each context in sequence?

We close with a few thoughts about these questions. Our belief is that everyone has unlimited potential to become great generalizers, and that any knowledge item can be generalized for later use. To do this one needs to do the following

- Ensure that new generalized knowledge is built on existing generalized knowledge
- Use all steps of the Learning Process Methodology to support generalizing, as it requires strong comprehension and understanding be developed through the entire learning process
- Seek problem-solving contexts for applying generalized knowledge, since working expertise is required for quality problem-solving performance
- Treat generalized knowledge as a level of learning where identification of cues is critical for producing and later using generalized knowledge in a variety of learning and problem-solving contexts
- Confirm generalized knowledge is achieved by testing against existing performance criteria and through self-assessment

We believe that applying each of these principles will be necessary when pursuing any of the future research questions have proposed.

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APPENDIX A. Levels of Learning Required for Generalizing Knowledge

Defining progressive levels of learning helps learners and facilitators identify intermediate stages of knowledge on the way to building generalized, transferable knowledge. Each level of learning corresponds to different steps in the methodology and can be used to provide expectations for quality or means to measure whether the level has been achieved. In Table A.1, we have updated the levels of knowledge across knowledge forms by editing and adding rows to Nygren's table (2007a). We have mapped these onto the MGK in Table A.2.

Table A.1 Levels of Knowledge Across Knowledge Forms (to measure level of learning)

Concept	Process	Tool	Context	Way of Being
Level 0.5 Pre-Informational (Language) *Describes meaning in own words*				
Knows meaning of key words	Follows grammar, syntax, or sequence	Recognizes key symbols Identifies functions	Decodes acronyms Recognizes semantic meaning	Recognizes cultural value
Level 1.0 Informational *Memorizes and recalls information: Assesses quality*				
States facts and definitions Draws pictures and diagrams	Describes steps in a method using an example Initiates use of a method	Uses step-by-step instructions Recognizes purpose and intended use	Repeats stories Describes events	Follows conventions Responds to traditions
Level 2.0 Comprehension (Why, Meaning, Significance) *Produces good inquiry questions; Analyzes models effectively*				
Articulates understanding Describes relationships and linkages	Rationalizes use of steps Knows criteria for quality outcomes	Comprehends instruction sets Knows full range of use	Condenses a story Describes significance	Values its importance Values expertise
Level 2.5 Implications, Bounding, Contradictions, and Completeness Very aware of concerns; Seeks counterexamples				
Sees linkages Seeks underlying principles	Justifies sequencing Clarifies issues	What makes it efficient and effective Appropriate usage	Shares implications Synergizes stories	Relates to other ways of being Sees inherent challenges
Level 3.0 Low Level Application *Applies in a familiar context; Describes results*				
Selects appropriate knowledge Identifies principle used	Documents use of steps in a method Links steps together	Applies instructions Uses basic functions	Recontextualizes for similar situation Seeks essence	Notices value produced Notices negative reactions
Level 3.4 Medium Level Application *Applies in a similar context; Compares differences*				
Identifies issues Adds another principle	Focuses on difficult steps Tests results	Expands function use Explores features	Sees implications Sees discrepancies	Starts to produce value Starts behavioral change
Level 3.7 High Level Application *Applies in different contexts; Identifies contexts*				
Clarifies boundaries Identifies key principles	Internalizes use of a method Links with other processes	Uses hidden features Adapts instructions	Responds to subtle prompts Writes an interpretation	Conscious use Developing pleasure in behavior
Level 4.0 Low Level (Generalized Knowledge) *Efficient in producing quality results; Has working principles*				

Concept	Process	Tool	Context	Way of Being
Generalizes understanding Has issues identified	Mental Checklist Validates results	Internalizes functions Aligns use to context	Provides prompts for others Presents alternative interpretations	Interacts with larger community Professional
Level 4.0 High Level (Working Expertise) *Proposes criteria to define quality; Tackles problems others can't*				
Evaluates alternative models Synthesizes with other concepts	Customizes methods for future use Monitors quality in real time	Debugs fluently Creates customized tools	Serves as an analyst Writes a white paper	Serves as a role model Mentors others

Table A.2 Mapping Levels of Knowledge onto the MGK

MGK Step	Learning Level	Explanation
1: Confirm Knowing	High 2	Learners test the quality of their own level of learning before going to application.
2: Familiar context	Bridge from 2 to 3	**Test and enrich fundamental understanding.** Choose a context so familiar one can use the situation to clarify understanding.
3: Similar context	Low 3	**Contextualize the knowledge.** Pick another different context that is similar (not as familiar) to test ability to move the knowledge.
4: Different context	3	**Choose an original context with key differences from the previous context.** The context should provide a challenge.
5: Unfamiliar context	High 3	**Transfer knowledge to a far context.** Thinking like a consultant, take the most highly complex situation anyone might face and determine how they could make use of this knowledge to produce value.
6: Cues	High 3	**Inventory cues for why the knowledge produced value in each context.** Explore and identify additional appropriate cues indicating why this knowledge can produce value and what conditions make it possible. Update list.
7: Underlying principles	Bridge to 4	**Inventory principles (rules) used in each of the previous steps.** What had to be true to apply the knowledge effectively in these contexts?
8: Make the generalization	Generalized Knowledge: Low 4	**Generalize understanding** through reflective thinking and writing.
9: Confirm working expertise	Beginning Working Expertise: Low 4	**Reapply this expanded expertise back through all contexts.**