FED-UP WITH FEEDBACK: WHY FEED-FORWARD MATTERS MORE IN WICKED LEARNING ENVIRONMENTS

Tim Dassler[1,2*], and Tove Dahl[1,2]

1 CARE Center for Avalanche Research and Education, UiT The Arctic University of Norway, Tromsø, Norway
2 Department of Psychology, UiT The Arctic University of Norway, Tromsø, Norway

ABSTRACT: The concept of the "wicked learning environment" has gained significant traction in avalanche education, where the spatial variability of the snowpack, the rarity of fatal feedback, and the potential for misleading positive outcomes are cited as features that make the winter backcountry uniquely difficult for learning. This paper argues that while avalanche terrain undeniably sits at an extreme position on the wickedness spectrum, the underlying pedagogical problem it presents is not unique to the mountain environment. Drawing on educational psychology, situated learning theory, cognitive apprenticeship, and reflective practice, we argue that raw feedback, whether from a graded essay or an untracked snowfield, never guarantees learning on its own. Learning benefits from interpretive mediation: a teacher, guide, or mentor who can supply the framing, the vocabulary, and the debriefing structure that transforms experience into competence. Empirical avalanche education research suggests that current course structures, designed primarily for information transfer, may produce overconfidence without commensurate skill development, consistent with the outcome the cognitive apprenticeship literature predicts when guided reflection is absent. The implication is not merely diagnostic but actionable: the challenge of avalanche education is best understood not as a problem of environmental wickedness but as a problem of insufficient learning architecture and mentorship.

KEYWORDS: wicked learning environment, avalanche education, mentorship, cognitive apprenticeship, reflective practice, expertise development

PRACTITIONER HIGHLIGHTS

- ✓ The mountain can tell you what happened. Only a mentor can tell you why it happened, and what to do differently next time. Avalanche education needs to be designed around that gap.
- ✓ A slope that doesn't release an avalanche tells you nothing about whether your decision to traverse it was good. A mentor who debriefs that decision does. We have built avalanche education around the slope. We should build it around the goal, the reflection and the debrief.
- ✓ Finishing a recreational avalanche course does not make someone a safe backcountry traveller: it makes them a beginner with a certificate. The real education starts on the next tour, with more experienced companions who are willing to think out loud in feed-up, feed-back and feed-forward ways. Course designers and instructors should be explicit about this.

* *Corresponding author address:*
Tim Dassler, Center of Avalanche Research and Education, Department of Psychology, UiT The Arctic University of Norway, PO Box 6050 Stakkevollan, NO-9037 Tromsø, Norway;
email: tim.dassler@uit.no

1. THE WICKED ENVIRONMENT: A CONCEPT WORTH QUESTIONING

In a widely-cited anecdote recounted by Hogarth (2001, drawing on Thomas, 1983), a celebrated New York physician earned a reputation for diagnosing typhoid fever in its early stages, by palpating patients' tongues. His diagnostic record was striking, and, as a colleague eventually realized, self-fulfilling: he was himself the vector, each individual examination a new transmission. Repetitive success had taught him exactly the wrong lesson.

This image, of experience systematically reinforcing error, has become a touchstone for an important body of work in avalanche education. The backcountry, especially the wild winter mountains, researchers and practitioners have argued, is a wicked learning environment (Johnson et al., 2020; Roach, 2024): one in which feedback is absent, delayed, or actively misleading (Hogarth et al., 2015); in which poor decisions are routinely rewarded with bliss and beautiful skiing; and in which the rarity of catastrophic outcomes and accurate feedback makes it nearly impossible to calibrate risk through personal experience alone.

This characterization is largely correct. But it invites a question that the avalanche literature has been slow to ask: is backcountry terrain categorically different from other learning environments, or merely different in degree? Is the classroom with all its variations of grades, rubrics and teacher feedback always a kind environment? Are the winter mountains, with their terrain, snowpacks, weather conditions and backcountry visitors always a wicked learning environment? When not, what does that imply about the nature of teaching and learning in the mountains?

This paper argues three things:

- First, that the kind-wicked distinction is best understood as a spectrum, and that most real-world learning environments, including formal classrooms, sit considerably closer to the wicked end of the spectrum than is commonly assumed.
- Second, that in all learning environments, kind or wicked, the decisive element is not the environment's feedback structure but the presence of an agent who can mediate, interpret, and contextualize experience.
- Third, that this reframing carries direct and actionable implications for the design of avalanche education: the primary challenge is not the mountain's wickedness but the absence of feed-forward in current course structures, and mentorship is how that absence is best remedied.

2. WICKED, YES. EXCEPTIONAL, NO: THE COMMON CONDITION FOR HUMAN LEARNING

Hogarth, Lejarraga, and Soyer (2015) formalized a distinction between two types of learning environments, developed over three decades of work on how environments shape what we learn from experience (Einhorn & Hogarth, 1978; Hogarth, 2001). Kind environments are characterized by close matches between the learning setting, where information is acquired, and the target setting, where it is applied; feedback is accurate and plentiful, and it links outcomes directly to the actions that produced them. Well-defined games, like chess, are canonical illustrations in the broader literature (Kahneman & Klein, 2009; Epstein, 2019): each move produces a clear, prompt consequence that can be linked directly to the action that caused it.

In wicked environments, the match between learning and target settings breaks down. Hogarth and colleagues (2015) describe several ways this can happen: the learner may encounter only a filtered or biased subset of situations, the composition of the relevant reference class may shift unnoticed between learning and application, or, most destructively, the learner's own actions, like that of the New York physician, systematically bias the feedback they receive, producing a self-fulfilling confirmation of a false understanding or model of the world.

What is often lost in the transmission of this framework is that its authors never intended it to be interpreted as a binary. Rather "kindness and wickedness can vary in degree as on a continuum" (Hogarth et al., 2015, p. 380). Their stated aim in that article was classification, not a claim that learning environments sort cleanly into two bins. The avalanche literature has largely inherited the taxonomy while leaving the continuum behind. Recovering it is not a critique of the framework but a return to it. The continuum point matters: it invites us to not treat avalanche terrain as a category apart, demanding special explanatory frameworks, when it may sit at one end of a continuum that includes the economics classroom, the clinical ward, and the writing workshop. Most real-world learning environments, as Epstein (2019) has emphasized, fall considerably closer to the wicked end than to the paradigm cases of chess

and golf. But they also rarely exhibit the extreme wickedness of financial forecasting or avalanche terrain, where negative feedback can be catastrophic and rare at the same time. If, indeed, wickedness admits of more and less, then the relevant question for avalanche education is not whether the mountain is wicked but what can be done to move the learning situation along that continuum and in the learner's favor.

Hogarth and colleagues (2015) draw exactly this conclusion, though in a direction the avalanche community has not followed. Because kind environments are a necessary condition for accurate inference, they argue, the practical implication is to construct kindness deliberately. The mountain itself cannot be engineered in this way, at least not in the wild and unmanaged winter backcountry. But the learning situation surrounding it can be, and we argue below that mentorship, articulation, and structured reflection are precisely how this is done in the field: the human-mediated equivalent of the kind setting Hogarth and colleagues argued for.

So, the wicked environment is not exceptional. It is, in important respects, the common condition of human learning.

Indeed, examining Hogarth et al.'s (2015) own taxonomy of mismatch types reveals how many everyday learning environments qualify as at least partially wicked. When the learner's sample of experience is unrepresentative of the population they will later face, they are in a wicked environment; a condition that describes the first-year (and often the last-year) medical student learning predominantly on unusual inpatient cases, the language learner whose input comes from textbooks rather than authentic conversation, and the backcountry skier whose experience is concentrated in one terrain type across a narrow range of conditions. When the relationship between outcome and decision is confounded by chance, for example, when you ski the slope and it does not slide, regardless of your assessment's accuracy, the environment is wicked. But this, too, is a familiar pedagogical structure: the student whose grade reflects a teacher's interpretive idiosyncrasy rather than the quality of their own work, or whose score on a standardized test reflects the particular questions chosen that day.

Wickedness, in other words, is not only a property of the mountain. It is a property of the relationship between the mountain and the learner.

3. INFORMATION ≠ FEEDBACK: THE IMPORTANCE OF PEDAGOGICAL INFRASTRUCTURE

If the kind-wicked framework reveals a spectrum, it also contains an underexamined assumption: that clear feedback, when it occurs, naturally produces learning. The educational psychology literature offers a significant challenge to this premise.

Sadler's (1989) foundational analysis of formative assessment drew a sharp distinction between information and feedback. Information, Sadler argued, only becomes feedback when it is actively used to alter the gap between current and desired performance. A grade, a slope that does or does not release an avalanche, a patient who recovers or deteriorates; these are all examples of information. They become feedback only when the learner possesses the interpretive capacity to link them to specific decisions and modify future behavior accordingly. In other words, how we learn from any particular event is dependent upon our understanding of that event. Our understandings are constructed, and they can be scaffolded by others.

This insight was extended and empirically grounded by Hattie and Timperley's (2007) landmark review. Their influential synthesis identifies three components that must be present for feedback to support learning:

- "feed-up" (what is the goal?),
- "feed-back" (how am I progressing?), and
- "feed-forward" (what should I do next?).

The environment, however kind, is structurally best suited to supply the middle element: a signal about current performance. The framing of the goal and the direction forward require an interpretive agent. This is not a peripheral feature of good teaching; it is constitutive of the learning process itself.

Feedback is among the most powerful influences on learning, but its effects are highly variable. Hattie and Timperley (2007) draw on a large meta-analysis by Kluger and DeNisi (1996) which found that feedback helped performance on average, but made it worse in more than a third of cases. What matters is not whether feedback is given, but whether it is correctly calibrated, contextualized, and acted upon.

Schön (1983) generalized this problem across professional practice. His critique of "technical rationality", that is, the idea that professionals apply research-derived rules to clearly-defined problems, is that it fails to describe what practitioners actually do in the field. Real professional situations are often characterized by complexity, uncertainty, instability, uniqueness, and value conflicts. The skilled practitioner does not apply pre-formed rules but engages in a reflective conversation with the situation: observing surprise, testing hypotheses, revising understandings. Crucially, this reflective capacity is itself a learned skill that can be modelled by experienced practitioners and developed over time through guided practice.

The guide who pauses to articulate their reasoning, the instructor who asks, "why did you choose this aspect?" or “why was this slope safe to ski?” (Dassler et al., 2025) rather than delivering a verdict; these are precisely the acts of reflective mediation that Schön describes.

What this literature collectively reveals is that "kindness" in a learning environment is not primarily a property of the environment itself but of the pedagogical infrastructure surrounding it. A classroom equipped with a thoughtful teacher who contextualizes assessment criteria and provides targeted feed-forward is a kinder learning environment than one without; not because the subject matter has changed, but because an interpretive agent has made the feedback intelligible. The mountain, similarly, does not become more learnable because the terrain is simpler; it becomes more learnable when an experienced guide or mentor affirms the goal, makes their reasoning around movement towards it visible, identifies what the day's evidence does and does not support for action, and structures a debrief for reflection and abstraction. In both cases, the decisive variable is the human in the loop.

4. AVALANCHE EDUCATION’S BLIND SPOT: KNOWLEDGE DETACHED FROM PRACTICE

Two bodies of theory converge to explain why this is so, and to suggest what better-designed learning architectures might look like.

Lave and Wenger (1991), in their influential account of situated learning, argued that learning is never only an individual cognitive transaction with an environment. It is a process of social participation; of moving, through gradually increasing engagement, from the periphery of a community of practice toward full membership in its ways of acting, seeing, and making sense. They termed this process Legitimate Peripheral Participation (LPP): newcomers initially take part in simple and limited tasks that are nonetheless productive and necessary to the community, absorbing the vocabulary, norms, and perceptual habits of experienced practitioners through proximity and guided engagement. Expertise is not transferred from expert to novice; it is constructed over time through participation in a social world where expert practice is visible.

Crucially, Lave and Wenger were skeptical of formal schooling as a site of genuine, situated learning, especially when it decontextualizes knowledge from the practice it is meant to support.

The same critique applies to a bounded two-to-three-day avalanche course: it imports classroom structure into a domain where knowledge is fundamentally situated in the mountain environment, in the snowpack, in the group and in the accumulated perceptual habits of an experienced practitioner. The Level 1 course initiates the novice into the community of practice: its vocabulary, its frameworks, its habits of attention. It does not complete the process. The deeper learning happens in the field, over multiple seasons, under the guidance of more experienced companions (or mentors) who know how to make their reasoning explicit, and do so. Stewart-Patterson (2014), in a two-season study of 35 heli- and snowcat-ski guides, described this trajectory in ski-guiding terms: because the environment does not reliably deliver representative feedback, he argues that guide-level expertise must be built through observation of lead guides' reasoning, structured debriefing, and team-level decision analysis in evening meetings, rather than through accumulated solo exposure.

Collins, Brown, and Newman (1989) offered a complementary analysis in their framework of cognitive apprenticeship. Their core observation was that modern schooling, by rendering cognitive skills abstract and decontextualized, makes expert thinking invisible to students. An expert reader, writer, or mathematician does not consciously execute visible steps; they draw on tacit knowledge that is inaccessible to the novice through observation alone. Cognitive apprenticeship proposes a sequence of teaching methods designed to make this tacit reasoning visible: modelling (the expert performs the task while making their thinking audible), coaching (the instructor provides targeted feedback during the learner's own attempt), scaffolding (graduated support progressively withdrawn), articulation (requiring the learner to verbalize their reasoning process), reflection (comparing one's own process to an expert's), and exploration (increasingly independent problem-setting and solving).

In the avalanche education context, each method has a direct analogue. Modelling occurs when an instructor digs a snow pit and articulates their interpretation in real time, rather than simply demonstrating the technique and announcing a stability rating or a go/no-go verdict. Coaching occurs when an experienced guide observes a student selecting a route and asks targeted questions before, not only after, the decision is made. Articulation occurs when students are required to justify their terrain choices aloud (e.g. asking “why was it safe to ski that slope?”), making implicit reasoning available for examination. Reflection occurs whenever the group pauses to examine what was known, what was assumed, and where luck may have substituted for skill. This can happen mid-route, at a transition, or in a post-trip debrief. Exploration occurs when a learner, under decreasing supervision over multiple seasons, begins to set their own learning agenda.

What cognitive apprenticeship most clearly offers is what the mountain itself does not. Tacit expert knowledge (the experienced forecaster's danger pattern recognition, the guide's immediate cognition that conditions have shifted, the practitioner's calibrated sense of uncertainty) is not a property of the environment but of the expert's perceptual and reasoning apparatus. It becomes teachable only when externalized: when an experienced practitioner thinks aloud, articulates their uncertainty, and models the process of looking for assumption-contradicting information and updating an assessment in light of new evidence. Without this externalization, the novice observes outcomes, not reasoning processes, and learns to associate those outcomes with their own actions rather than with the specific features of the situation that invoked these processes.

5. CONFIDENCE WITHOUT COMPETENCE: AN UNCOMFORTABLE INSIGHT

The theoretical argument outlined above finds direct empirical support in research on the effectiveness of formal recreational avalanche education, research that will be familiar, and may be uncomfortable, to an ISSW audience.

McCammon (2000), in a review of recreational U.S. avalanche accidents, found that victims with basic formal avalanche training exposed themselves to more hazard than any other group, including those with no avalanche awareness at all. The risk reduction attributable to formal training was concentrated in improved mitigation behaviors (such as carrying rescue gear, spacing on slopes) rather than in exposure reduction. His subsequent 598-accident analysis (McCammon, 2002) refined the picture: trained victims were no more hazard-exposed on average than untrained ones, but they were substantially more susceptible to heuristic traps such as familiarity or social proof. Courses, in other words, conveyed mitigation routines and a vocabulary of hazard but did not alter the intuitive cues that drove terrain-entry decisions.

More recent research confirms and refines this picture. Dassler et al. (2025) found that even a lengthy season-long avalanche course may be insufficient to produce lasting changes in how participants integrate snow observation into their safety judgements, particularly among those who are not already motivated by snow assessment. A Montana study of introductory course participants (Greene et al., 2022) found that inexperienced riders gained confidence at a faster rate than experienced ones, with both groups converging on similar post-course confidence levels despite different baseline experience, a pattern Oskamp (1965) identified six decades earlier: increasing information reliably increases confidence, but accuracy quickly reaches a ceiling.

Taken together, these studies describe a recurring pattern: courses reliably produce confidence; they less reliably produce the interpretive capacity that would justify it. That pattern, confidence without commensurate skill, is consistent with what the cognitive apprenticeship literature would predict when a wicked learning environment is addressed primarily through information transfer rather than guided reflection. The course conveys content, and that content contributes to confidence. But without structured debriefing, that is, without the articulation, reflection, and guided comparison between novice and expert reasoning that Collins et al. (1989) identify as essential, the learner may return to the field with enhanced confidence yet unimproved interpretive capacity. The mountain's feedback remains opaque. Its most common feedback, no avalanche at all, is the least informative.

This insight also reframes the temporal challenge of developing avalanche expertise. The Kahneman and Klein (2009) formulation is precise: expertise requires both a learnable environment and an adequate opportunity to learn its regularities. Opportunity is not primarily about time in the field but about the quality of the learning infrastructure during that time. A season with a mentor who systematically scaffolds and debriefs decisions and helps distinguish signal from luck will produce more expertise than several seasons of unguided experience, regardless of the latter's volume.

6. DESIGNING FOR FEED-FORWARD: BUILDING WHAT THE MOUNTAIN CANNOT PROVIDE

The wicked learning environment framework has been genuinely valuable for avalanche education: it explains why experience alone does not reliably produce expertise, why even skilled practitioners can be fatally mistaken, and why the mountain's apparent lessons are so often the wrong ones. Our argument is not that this framework should be abandoned, but that it should be extended and reframed.

Wickedness, we have argued, is not a property unique to the backcountry. It is the default condition of any complex learning domain where feedback is ambiguous, outcomes are partly random, and expert reasoning is tacit. Successful classroom learning occurs not because it is an inherently kind environment but because, at its best, it is equipped with an interpretive infrastructure: teachers who supply feed-up and feed-forward, who, in their feedback, make criteria and reasoning visible, and who help learners distinguish what they know from what they merely believe. The mountain cannot provide this infrastructure on its own. Neither can a three-day avalanche course. Not because the content is wrong, but because the approach is.

The avalanche community is not the first to encounter this problem. Similar observations have emerged in other domains where learning takes place in complex, feedback-poor systems (Sterman, 1994). Current avalanche education is largely designed around a Safety-I logic: identify hazards, apply rules, avoid failure. This approach assumes that accidents are caused by flaws in a system and that the solution is to eliminate or avoid those flaws (Hollnagel et al., 2015; Ham, 2021). In complex and unpredictable environments, however, hazard avoidance is necessary but not sufficient. What wicked environments additionally require is a Safety-II capacity: the ability to actively monitor changing conditions, adapt in real time, learn from what is happening, and think ahead. Safety-II does not treat safety as the absence of accidents but as a continuously achieved outcome of a process maintaining attention, judgement, and adaptive response. This is precisely the capacity that mentorship, guided debriefing and reflection, and communities of practice are designed to build, and that information-transfer courses alone cannot.

Several practical implications follow directly from this reframing:

Structured reflection and debriefing should be treated as a core pedagogical component of backcountry skiing, not an optional supplement. The question "did we get lucky today?" is not rhetorical; it is the mechanism through which experience in a wicked environment is rendered learnable. Instructors and guides who model this question, and who normalize the epistemic humility it requires, are providing something no amount of classroom instruction can substitute for.

Long-term mentorship and communities of practice should be recognized as the primary vehicle for avalanche expertise development, **with formal courses serving as an initiation rather than a completion.** Course design should explicitly prepare learners for this longer journey, cultivating habits of observation, reflection, and acknowledging uncertainty rather than producing the illusion of standalone competence. Ideally, avalanche educators would provide learning infrastructures, such as mentorship programs, after a course.

Research attention should shift toward the quality of learning infrastructure and process, not merely the characteristics and content of learning environments. The key variables are not how wicked the snowpack is but how well the educational context provides what the environment cannot: visible expert reasoning, structured reflection, guided interpretation of ambiguous outcomes, and the gradual transfer of interpretive responsibility from mentor to learner.

Avalanche terrain is, in Hogarth's terms, genuinely wicked. But wickedness does not make learning impossible: it makes mentorship and reflective practice essential. That conclusion is not specific to the winter mountains. It is the oldest lesson in pedagogy.

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