

CREATIVITY IN PRACTICE

An Ecology of Practice - Making a Geological Map Norman Jackson

What does being a geologist mean?

Geology is the study of the earth, its rocks and landscapes and the processes that formed them. To perform the role of a geologist a person has to develop a body of knowledge that enables them to perceive (see, recognize, interpret and understand) the rocks, structures and landscapes they inhabit. They also have to develop the practical skills to describe and identify the rocks and structures in the field (and laboratory) and understand their relationships to each other. The 'ecology of field practice' can be illustrated in the way they make a geological map and report which is the problem used in this narrative.

How does someone become a geologist?

To become a geologist a novice learner must serve both a *cognitive and a practical apprenticeship*. The cognitive apprenticeship enables learners to develop the knowledge and ability to perceive, imagine and reason like a geologist. The practical apprenticeship enables the novice learner to develop the necessary practical skills in the contexts of the natural field environment and laboratory, to use their theoretical knowledge to the solution of real geological problems in real world environments. These integrated apprenticeships, together with the practical experiences they gain, enable the novice learner to develop the knowledge, practical skills, values and self- and ethical awareness required for practice as a geologist. These apprenticeships are normally undertaken as part of a university degree but extend into independent field and work experiences, and employment once the geologist has graduated.

Cognitive apprenticeship
"learning through guided
experience [in using] cognitive
and metacognitive [skills],
rather than physical skills and
processes"^{1:456}

How does a learner become a practitioner in a professional field?

Learning how to perceive the field environment in which the geologist works, and find meanings in what is perceived and then act appropriately on those understandings, is fundamental to being an effective practitioner. This perceptual understanding is not something that can be developed quickly. It takes years of education, training and personal experience.

Where learners are preparing to enter a field of professional practice we might draw upon the idea of *signature pedagogies*²⁻⁶ and *signature learning experiences* to describe the ways in which learners develop the understanding, awareness, cognitive and practical skills to productively inhabit a work environment.

According to Lee Shulman, who developed the idea of signature pedagogies, 'they are types of teaching that organize the fundamental ways of educating future practitioners, and are used to transfer skills of how *to think*, *to perform* and *to act* with integrity in their professional work'²

For Thompson and Hall⁶ signature pedagogies are: 1) *epistemological*- they deal with things that we have to know and know how to do 2) *ontological*- they are about the way we are in the world and the ways in which we orient ourselves to being and making meaning in the world and 3) *axiological*- concerned with value, worth, ethics and aesthetics. "Each of these elements cannot be separated out in practice, even though we might write about them separately in order to advance our understandings. The epistemological/ontological/axiological combination becomes a kind of 'indwelling'⁷ a tacit knowledge, which is conveyed as much through the presence of the practitioner and through the way that they orient themselves to questions and tasks, as it is about what they actually say and do. The combination of knowing, doing and being that are found in signature pedagogies is not separable into distinctive pieces which can be planned for, and learned/taught separately. Both epistemological and ontological learnings progress together, at the same time, and through one pedagogical practice."⁶ This reflects their integration in the practices of workers in the field.

Signature learning experiences are developed through signature pedagogies. They enable learners to inhabit environments that are identical or close to the environments they will encounter in their future professional world. They enable learners to develop the perceptual awareness they will need to interpret and act in the work environment in the way a practitioner would. This awareness is more than perception alone - we are in the words of David Krech⁹ 'perfinkers' - we perceive, think and feel together and all contribute to and are necessary for our knowing in a world of relationships and interactions.

Through signature learning experiences teachers acting as instructors, supervisors, mentors and coaches, bring learners into the presence of particular aspects of the environment that they deem relevant and important in order that the learner might perceive and react to these things and develop new relational understandings, *'When the novice is brought into the presence of some component of the environment and called upon to attend to it in a certain way, his task, then, is not to decode it. It is rather to discover for himself the meaning that lies within it. To aid him in this task he is provided with a set of keys in another sense, not as ciphers but as clues'*^{8:20} *'Meaning is there to be discovered in the landscape [or environment], if only we know how to attend to it. Every feature, then, is a potential clue, a key to meaning rather than a vehicle for carrying it.'*^{8:208}

For example, field education in social work^{10:330} *'students learn to practice the profession through an apprenticeship supervised by expert practitioners... Contributions from adult learning theory'^{11,12} ..provide the theoretical underpinnings for field education. Specifically, students learn to practice the profession through active involvement with "real" experiences in which they perform a service or helping role, and opportunities are provided for study of their practice..... Students' "real" practice can be accessed directly by observing, listening to audiotapes, or watching video.'*

This way of participating in supervised learning experiences to solve problems that a professional in that field might encounter, may be combined with other pedagogical and learning practices. For example, in social work field education^{10:330} *'Ideally, practice is studied through two interlinked processes. One is subjective reflection about students' understanding and reactions to the practice situation'¹³ The second process involves conceptualization of the practice situation and interventions, through making connections to theory, providing conceptual frameworks, and supplying explanations from the field instructor'^{14,15} Insights gleaned from these processes are then used to plan interventions for subsequent practice. Traditionally, the one- to- one field instructor and student educational or supervisory conference is the structure for enacting a wide range of pedagogical techniques to ground this view of student learning....'*

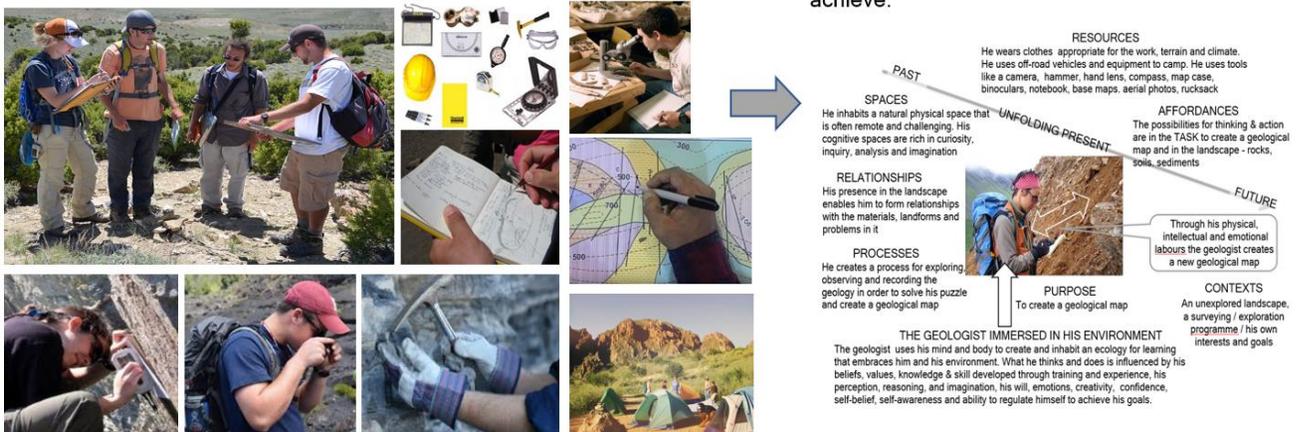
Figure 2 Visual explanation of relationships between signature pedagogy and signature learning experiences and ecologies of practice in geology education and practice

Signature pedagogies are the ways and means used by teachers in a disciplinary/practice field to develop the knowledge, awareness and capabilities of learners in that field so that can *think, perform* and *act* with integrity in their professional work.

Signature learning experiences are developed through signature pedagogies. They enable learners to inhabit and perceive the environment in which they practice in particular ways to find meanings in what is perceived and then act productively and with integrity on those understandings.

Example : In geology the *signature pedagogy* involves creating *signature learning experience* to enable learners to perceive the practice environment (called the field) in particular ways, use tools safely to help find meanings in what is perceived and then act on those understandings. In this way learners become aware of the ecology of learning in action and eventually are able to create their own ecology of practice.

An ecology of practice - enables a geologist to perceive and engage with his environment in particular ways, to attend to the things that matter to him and enable him to learn and achieve.



How does a geologist learn to productively inhabit his work environment?

Relationship between signature pedagogies, signature learning experiences & learning ecologies

Through signature learning experiences a learner who is becoming a geologist comes to know, in an experiential and embodied sense, how to create and make use of an *ecology* for perceiving and interacting with the environment to engage with, imagine and solve the problems and opportunities it provides.

The *signature pedagogy* involves all the things teachers' do to create an ecology within which learners develop their observational skills and practical capabilities for making a geological map. This will include teaching in field, classroom and laboratory situations, modelling behaviours, safe working practices and thinking processes, and demonstrating how tools are used to gather geological data.

One of the most important signature pedagogies of geology teachers involves facilitating *signature learning experiences* that enable learners to develop the necessary skills, ways of perceiving and thinking, and the dispositions to inhabit and structure the environment in ways that enable them to *create* a geological map. The signature learning experience includes the use of tools and recording procedures to gather relevant information and the production of new artefacts.

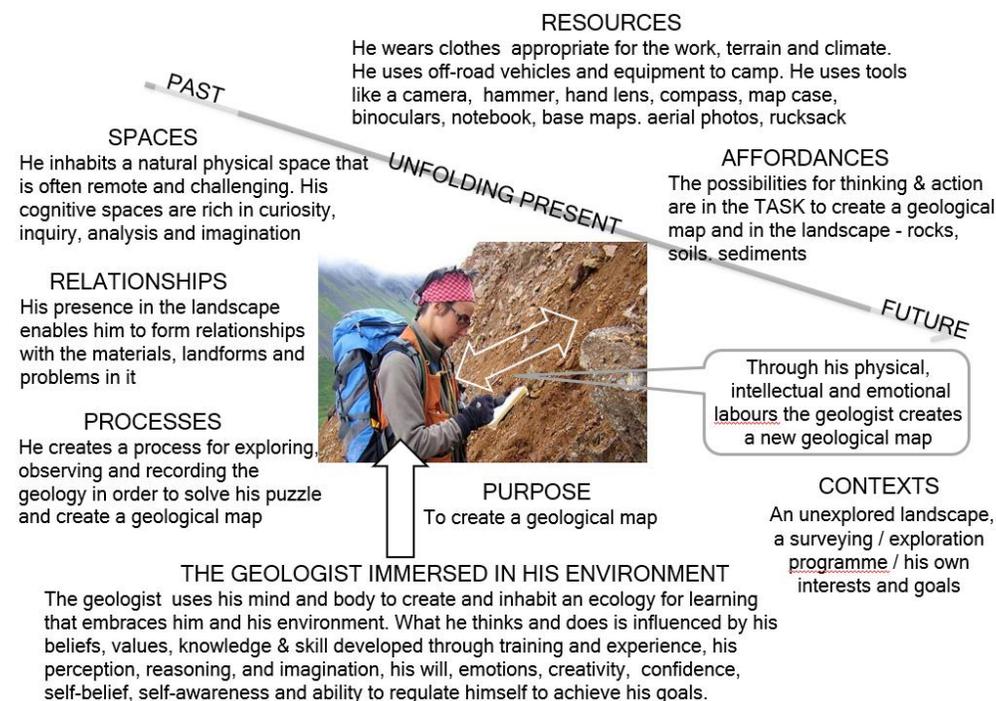
When this is achieved independently of the teacher the learner has created their own ecology for practice that enables them to learn and achieve the goal of making a geological map. They

have learnt how to create an ecology for solving their problem through the experience of doing it themselves and this experienced-based knowing can be drawn upon in future situations. Figure 2 shows the relationship between signature pedagogy, signature learning experiences and learning ecologies.

What does an ecology of practice for making a geological map look like?

Making a geological map is a typical challenge that a geologist will encounter in his professional work. It requires him to create an ecology to engage with and solve his problem. Using the framework provided in Figure 1 we can identify the elements of the geologist's field-based ecology of practice for making a geological map (Nb the complete ecology will also contain elements that are desk- and laboratory-based).

Figure 3 A field geologist's ecology for embodied learning in order to make a geological map^{16,17}



We might represent this scenario through a map of the geologist's relationships and interactions with his task, the natural field environment in which he undertakes his task, his past perceptual and experiential history (including his signature learning experiences) and his emergent thinking and emotions as he engages with his challenge in an unfolding present (Figure 3^{16,17}). His self-created learning ecology is directed to accomplishing the proximal goal (understanding the geology/creating a map) connected to more distal goal of becoming the geologist he wants to become. His learning ecology comprises himself, his environment, his interactions with his environment and the learning, development and achievement that emerges from these interactions. It includes the intellectual spaces he creates for himself, his work processes, activities and practices, his use of tools and technologies^{18,72}

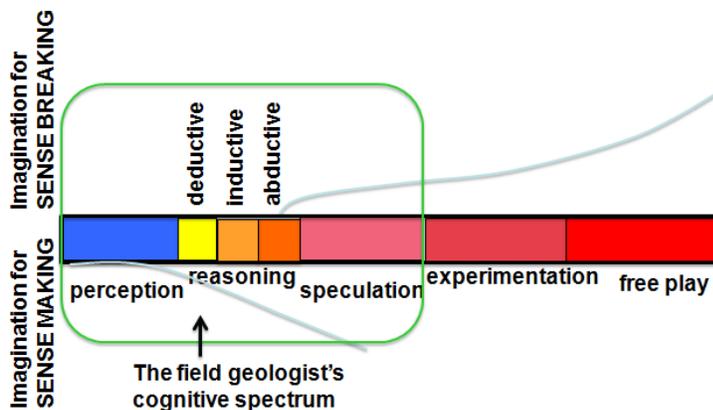
His ecology of practice involves him physically covering the ground and gathering and processing lots of information through particular routinised actions - like locating the position of a

rock outcrop on a geographic map or aerial photograph, measuring the dip and strike of bedding or other structures in rocks, breaking rocks and examining fresh surfaces with a hand lens and perhaps testing them with dilute HCl, photographing and sketching rock outcrops and annotating sketches with observations, and where there is little outcrop examining the soils. In these actions he is searching for meaning in his environment. Meaning that has been learnt through years of study and practical experiences in a range of environments.

The mental processes of perceiving, imagining and reasoning enable him to develop hypotheses about what is being perceived and these are intermingled with the actions and activities that enable him to test his theories, to find the pieces of the geological puzzle (rock outcrops and structures), sense (observing, feeling, measuring) the materials, and record (often sketching or photographing and making notes) what has been perceived. In this way ideas about the geology are tested, advanced or abandoned.

The geologist's thought processes move backwards and forwards along the cognitive continuum¹⁸ (Figure 4): perception (observation informed by knowledge gained through study and experience), imagination (conceptualisation of what is observed in order to create possible meanings) and reasoning (the critical evaluation of what is observed in order to evaluate possible meanings and make judgements) and reflecting on what has been seen and understood to try to make more or different senses of it.

Figure 4 Representation of the cognitive spectrum developed by Ann Pendleton-Julian¹⁸ The typical cognitive spectrum of a field geologist is represented by the green domain



Making a geological map is like solving a giant jigsaw puzzle where most of the pieces are missing. The geologist's learning project is one of continuous inquiry driven by his

curiosity and need to understand. His project requires all forms of reasoning and the use of imagination to speculate and project from the known into the unknown to try to visualise and make sense of the patterns and the stories he is seeing in rockscape. This is the nature of the intellectual space he creates to understand his problem while physically interacting with the physical space of his natural environment.

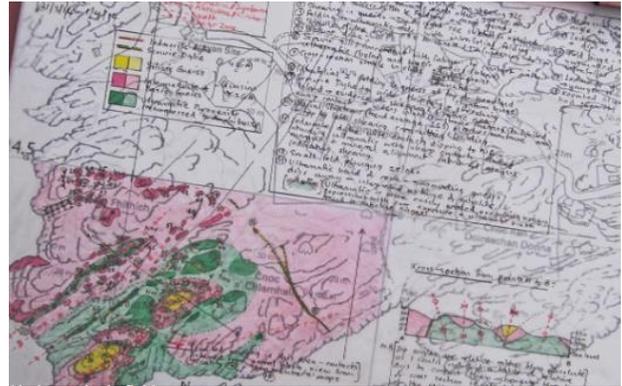
This act of 'making a map' is also an emotional experience. He experiences joy in the work he is doing: he loves the challenge and he likes solving the puzzle which sustains his motivation. But he can also experience feelings of frustration when he has to spend hours searching for answers but cannot find them. At times it's uncomfortable. In his field area it rains a lot so he is constantly wet and it's not easy to keep his field slips and map dry. And it can be painful as

slipping and falling is part and parcel of the scrambling over the loose rocks and occasionally as he pushes himself to climb a cliff he feels anxiety and fear.

These complex sensory experiences and intense interminglings of the physical, mental and emotional states of being enable him to form deep relationships with his work and the objects of his work - his landscape and the rocks in it. His emotions contribute to the investment he is making in his own meaning making process and encourage a sense of inner resilience as he pursues his goals in what is a fairly inhospitable environment.

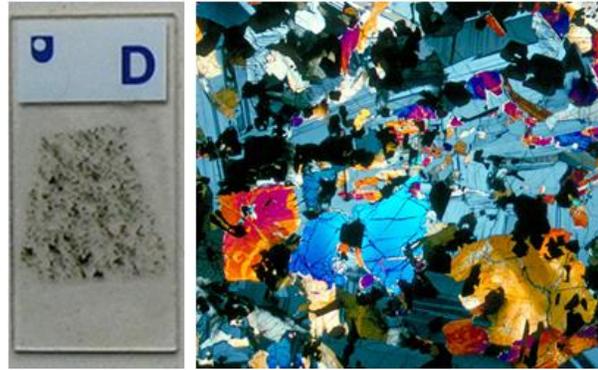
The geologist embodies his learning. He needs to get his body and engage his senses and his mind to the places he needs to be in order to find the evidence that confirms his hypothesis or not. He has to get himself into the physical spaces that have the highest potential for solving his problem and then know how to behave to enable his senses to gather the information he needs. While this is essentially a logical process my own experience has shown me that there is much intuition involved in this process. Sometimes it just feels right to do something without really being able to immediately explain why. In such situations we might attribute such actions to creativity.

The geologist accurately records his field observations on a field slip (right) and in his notebooks. The process enables him to relate and synthesise disparate pieces of information to create a clearer and bigger picture of his puzzle and enable him to search more selectively for missing pieces. Notebooks containing field sketches can be like artists' sketch pads full of aesthetic and emotional value as well as scientific meaning.



Once back at camp, there is further pondering and reflection on what has been seen as the day's observations in notebooks, digital photographs or video, are revisited and plotted on a cleaner base map like the one on the left.

These analytical and conceptual processes continue after the field experience as rock samples are analysed and understood better. New artefacts and data are produced through these analytical processes. For example, geologists use microscopes to study the mineral composition, textures and structures of the rocks they have sampled using thin transparent slices of rock (30 microns thick). Thin sections (example right) are important artefacts produced from natural materials that reveal the beauty in the rocks and minerals



and enable those materials to be understood, characterised and classified. Through laboratory study the accuracy of the geological map and report the geologist is producing can be improved.

How does creativity feature in this ecology of practice for *creating* a geological map?

As can be seen from this description of a geologist's ecology for creating a geological map, the map is the intellectual and creative product of his interaction with his environment and the materials that are in it using the tools and resources available to him.

In this interaction there are many affordances for creativity and many tangible expressions of personal creativity. Some of these expressions emerge in products or artefacts (maps and reports) that can be valued and appreciated by others who have the knowledge to understand the meaning in the product. But some of these expressions are revealed in the narrative of the means by which learning and achievements were accomplished ie the story of the ecology that he created to engage with his problem.

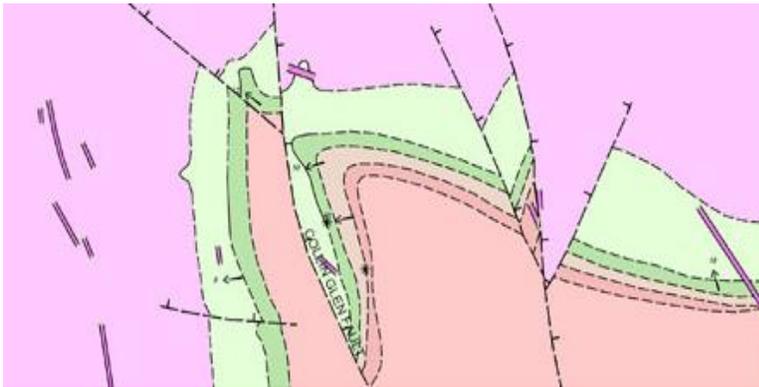
The question we are interested in exploring is how does a person make use of their creativity when they are engaged in the sort of disciplinary problem solving described above? When they are deeply immersed in a disciplinary problem and the environment in which both they and their problem are located.

Here we might draw on the ecological definition of personal creativity proposed by Carl Rogers which he considered is 'the emergence in action of a novel relational product growing out of the uniqueness of the individual on the one hand, and the materials, events, or circumstances of their life'¹⁹

In the scenario described above the field geologist in a relationship with his environment and his problem *creates an ecology* that embraces the circumstances of his life - at least those aspects that relate to his project to create a geological map. This aspect of creativity - the process by which something new/novel is brought into existence, is often overlooked. While all geologists will use standard procedures and routines like those described above the problem is tackled and way understanding is constructed will vary between different geologists and here there is scope for personal creativity. As the geologist's thought processes move backwards and forwards along the cognitive continuum⁶ (Figure 4) the intermingling of perception (observation), imagination (conceptualization) and reasoning (critical evaluation) offer endless possibilities for the creation of meaning.

The intellectual, emotional and physical struggle of a geologist is focused on trying to solve a three dimensional puzzle with only bits of information and lots of gaps. He tries to understand the relationships between one type of rock and another and develop understanding of the geological history of the area. It's an ecological problem! Perceiving, conceptualising - the building of working hypotheses to explain the geology, and reasoning go hand in hand and as a hypothesis forms the body is involved in helping the geologist to evaluate it. Given this rich and dynamic cognitive and emotional environment it would not be surprising for sudden ideas emerge which a geologist might attribute to a *creative insight*, when all the time possible answers and solutions to problems are jostling for recognition and application.

The elements of a geologist's cognition and bodily actions work together in a merry dance through field, laboratory and office environments and the knowledge and understanding that is developed is communicated in maps and reports that are the tangible creative products of his ecological process. The final product of this process - a geological map and report is the geologist's way of communicating his understandings to other geologists or people working in related professions like civil engineering, planning, mining engineering or hydrogeology.



Producing the geological map is essentially a drafting process in which information is carefully transferred from field maps and notebooks onto a new base map and digitised.

The process of reworking this information can stimulate further integrative thinking. But there is also an artistic element in the making of a map as pens or digital tools are handled and used to create the map. The final product is a beautiful object containing a story, explained in the image, the key and in an accompanying report, about the geological history and mineral resources of an area. The map is also a tool that can be used to make decisions about how a landscape and its resources might be used and managed.

The digitised map and accompanying report are the creative artefacts resulting from a geologist's learning ecology. In the words of Rogers *'the[y] emergence in action' as 'novel relational product[s] growing out of the uniqueness of the individual on the one hand, and the materials, events, or circumstances of their life'*¹ Circumstances that the geologist, through his own history, learning and actions, has helped determine.

Through this narrative we can gain perspectives on what being creative means and on the nature of artefacts that are developed through the work process that involve the geologists creativity.

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