Chapter 3

What students learn from labs, studios, projects, and fieldwork

INTRODUCTION

The previous chapter looked at how students develop expertise with disciplinary content in higher education. It highlighted that experiential or practical learning is absolutely central to the process through which students work towards developing expertise in their discipline. This chapter focuses more closely on what happens in labs, studios, projects, and fieldwork, and looks in particular at the diversity of ways in which they are organised, what students are expected to learn, and how teachers teach these things. As with the previous chapter, a central question here remains what students need to learn from practical activities in higher education. In Chapter 2 we looked at the more obvious answer to this question: students should learn to use and apply the content knowledge that makes up their discipline and learn to perform the discipline's representative tasks, whether that means playing the violin, designing electrical circuits, teaching children, or analysing business data. However, one of the key themes of this book is that focusing only on the explicit content knowledge and process skills of a course can mean failing to develop the thinking skills that students are also expected to learn in higher education.

Underpinning the vast array of things students learn in practical courses are a number of *ways of thinking*. These ways of thinking include:

1. being able to use things they have learned in one context (such as in a class) in a different context (such as in the world outside of higher education),
2. investigating the world using the skills and approaches of their discipline,
3. finding solutions to problems which are often ill-defined or open-ended and may involve a range of constraints (including financial, technical, legal, and ethical constraints),

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4. professional skills like project management or working effectively in teams and alongside others,
5. managing their own learning to be able to continue to adapt to situations and challenges after they leave higher education.

Learning by doing situations are often expected to develop these skills by creating opportunities for students to connect real-life experience with the concepts and ideas from a discipline. These connections help students to make sense of those experiences and to develop the perspective and skills of experts in that discipline. This chapter takes a similar approach to a practical class in that it starts with lived experiences and then links them to concepts and ideas. The chapter is structured around a number of examples that are used to illustrate how the underlying thinking skills associated with practical work are brought to life in labs, studios, fieldwork, and projects.

ORGANISING LABS, STUDIOS, PROJECTS, AND FIELDWORK

Learning by doing takes place in a wide variety of settings. The following examples give a feel for the diversity of the settings where students can engage in practical learning in higher education. Since we use these examples to illustrate the concepts and ideas throughout this chapter, it is worthwhile to read all of them carefully, even if some of them may seem on the surface to be less directly relevant to your discipline or learning goals than others.

SPOTLIGHT 3.1.A – LEARNING IN THE MUSIC STUDIO

Gwen teaches a practical course in *musical composition* to student teachers who are learning to teach music in primary schools. In the course, students first work as a class of 30 to practically explore ways to compose, using a range of sounds including *found sounds* and body percussion. After this induction, students begin to work in groups to complete an initial composition activity which involves responding to a stimulus such as composing a piece of music to accompany a film or piece of visual art. After the seventh week of the term, the students work in groups to develop an original musical composition that they perform at the end of the semester.

Previously, Gwen has also taught an *advanced performance* studio in classical guitar on a bachelor's degree in music. The studios were based on a *conservatoire* model, where a teacher works with an individual student to help them develop the skills to deliver an end of semester recital, which ranges in length from 30 minutes to over an hour depending on the year of the student. In this course, students are focused on developing the technical ability, stamina, and musical and mental skills required to deliver an elite-level performance in a one-off, highly pressurised situation.

SPOTLIGHT 3.2.A – LEARNING TO DESIGN IT SYSTEM ARCHITECTURE

For a number of years, Cécile (one of the authors of this book) taught a course in *service-oriented architecture* to computer scientists. Although the course was taught to master's-level students, many of the students did not have much prior knowledge of IT architecture and so needed to learn about some of the basic concepts and ideas. The course was an optional one and was popular with some students because they liked the topic, and with others because *service-oriented architecture* was a *buzzword* in the industry at the time and students wanted to work as consultants in the field.

As part of the course, students completed a design project – their goal was to design an IT architecture that met a particular set of client needs. The exercises of the course were structured in such a way as to walk students through the stages of a design project. At each phase, students could use different tools (such as system modelling tools), and the exercises in the course allowed students to practice using these tools.

SPOTLIGHT 3.3.A – LEARNING TO MANAGE OPEN-ENDED PROJECTS

Roland (another of this book's authors) teaches a course in the social and behavioural sciences of learning. The course, which runs over a full academic year and is taught as an elective to a class of about 60 natural science and engineering students, begins by exposing students to both the key concepts in learning sciences as well as to the mechanics of relevant research techniques (like psychological experiments and social surveys) and to their associated statistical techniques. In the second semester, students are required to apply what they have learned by working on a team project.

The projects (which can be either research projects or design projects) are structured as *ill-defined problems*: students are given a broad problem statement and a *client*, and are asked to explore the problem statement with the client before clarifying exactly what problem they are going to solve. They then solve the problem by either completing some social scientific research or by designing an educational tool. Roland creates heterogeneous teams because learning to work with people from other walks of life and disciplinary backgrounds is one of the goals of the project.

SPOTLIGHT 3.4.A – CARRYING OUT SCIENTIFIC INVESTIGATIONS IN A LAB

Anne-Sophie runs chemistry labs for more than 300 students and manages dozens of teaching assistants. The labs have multiple goals: at one level students learn to physically enact particular procedures, following a set of instructions when working with a piece of lab equipment in order to answer a particular question. However, Anne-Sophie says, there is a lot more to the labs than just mechanically following instructions:

> If they just replicate the procedure, they aren't thinking and they forget everything quickly. They need to be thinking, to be making

> connections with the theory, and checking to see if it makes sense. This is something students have difficulty with – does their result make sense physically? Even if they end up working as quality control in a production line, it is quite automatic, but they need to know what a result means, how to interpret it, and how to test their interpretation.

As can be seen from the four cases above, practical learning in university covers a great diversity of settings. The size of practical learning classes ranges from one-to-one classical music studio tuition to an enormous pedagogical system involving hundreds of students and dozens of teaching assistants in a chemistry lab. The location ranges from a highly controlled lab to meeting with clients, potentially outside the university. The things that students learn and practice in practical courses range from physical acts like playing music or accurately manipulating lab equipment, to cognitive processes like statistical testing and systems modelling. In some cases, practical learning takes place in a very open-ended context where students create their own music or generate their own research and design questions. In other cases the tasks themselves are more tightly defined, such as following a particular procedure for manipulating lab equipment, or correctly applying particular statistical tests. In some cases the practical activity is a project within a course which also includes lectures: in other cases the practical is the whole focus of the course.

Despite these differences, there are evident similarities too. In all cases students are *doing*, whether that means designing something, playing something, composing something, or investigating something: they are not, for example, only reading about experiments in chemistry or in learning sciences, they are actually designing and carrying them out. In doing so, they are taking ideas, concepts, and techniques that they are hearing about in other courses and they are seeing how they look, feel, and smell, and what they sound like, in real-life settings. They are linking their physical movements to concept and ideas, and vice versa. This process of making connections between the meaning of different ideas (known as *deep processing of information*) and between ideas and real-world sights, smells, and feelings (known as *rich encoding*) is central to how learners form long-term memories that they will be able to recall when they need them. That is, they are central to effective learning.

It is also evident in all of the cases above that the students are learning things that they should be able to apply and use outside of the university classroom or lab. This is really explicit in Gwen's classes (when students are learning composition in order to teach it to primary school children, or are learning musical pieces in order to perform in public) and in Cécile's class (where at least some students are taking the class in order to work as consultants in the field). In the case of Roland and Anne-Sophie's classes, the specific contexts in which students may end up using these skills are perhaps less clearly defined, but it is nonetheless intended that students will be able to apply what they have learned. This ability to use what was learned in one situation in a different situation is known in learning research as *transfer*. Transfer, it turns out, is a major challenge for university teaching. Some 30 years ago, research in university physics teaching highlighted that students can learn the concepts, formulas, and algorithms they need to pass physics courses but then fail to use this knowledge when faced with questions which are phrased as *practical problems* and which don't require calculation (Hake 1998). Over the last three decades, research in other disciplines has found that this problem is not confined to physics or, indeed, to natural sciences. To put this in more straightforward terms, it is not easy to turn *book learning* into *practical knowing*. In each of the cases described above, experiential learning is intended to provide something of a bridge between the ideas learned in traditional classes and the ways in which students will use them in practice in the world outside the university.

LEARNING IN PRACTICAL SETTINGS

If the organisation of experiential learning is diverse, so too are the range of skills and the knowledge that students are expected to develop. As we saw in Chapter 2, knowledge and skills are typically deeply embedded in the specifics of the discipline. But there are also commonalities in learning goals that cut across different disciplines and across a range of different practical learning settings. These differences and similarities are explored below in the second part of each of the case studies.

SPOTLIGHT 3.1.B – LEARNING IN THE MUSIC STUDIO

Gwen's musical composition course provides a practical setting for students to apply a range of musical concepts like structure, dynamics, and timbre, as well as developing performance skills and listening skills such as being able to think in sound (called *audiation*).

Gwen says,

> The big challenge with the course is that the students are grappling with the idea of being *the composer*. Some have little prior musical experience but even those who do are sometimes at a disadvantage because their prior experience is often based on reproducing pre-existing musical works, in other words, playing pieces written by Beethoven or Bach or whoever. It is easy for those students to fall back into adapting and re-creating pieces in a pastiche style rather than fully engaging in the process of creative music-making.

This notion of *process* is central to this practical course. The process operates at four, inter-related, levels. At a micro-level, is the process of playing or making music. Gwen says "music is a temporal art – it passes through time". Unlike, for example, a painting which exists and can be experienced after it has been created, the experience of music is intrinsically tied to the process of *making* music. "Of course music can be recorded, but sometimes when music is being made in that moment there is a sense of what Csikszentmihalyi (1990) has called *flow* – a bit of magic – they're completely present in the performance". Learning the capacity to *be present* in the performance is part of what students need to learn in the course. The second-level process is the process of composing. Students who have prior musical experience in particular run the risk of imposing their implicit sense of *what works*, and so getting students to engage without preconceptions in the process of composing can sometimes be a challenge.

This challenge is associated with what happens at the third level of process: the level of group work. "Sometimes", Gwen says, "the really successful groups are those who are not experienced musicians. Because they have no prior expectations they find it easier to engage in the process. Prior experience is welcome, but it is not an advantage". Experienced musicians can end up short-circuiting the composing process, and this can cause tension and impact on the work of the group. Playing and listening as part of an ensemble is part of the skill set in music and is one of the activities of this practical. Hence, learning to work in a team is also a learned skill: "Students develop a whole series of extra-musical skills through the practical's teamwork, like skills in cooperating with others, patience, negotiation, empathy and leadership", says Gwen. While working within the group can be challenging, those who learn to work well in a group find it improves their work. The fourth level of process is the process of each student learning to manage their own thinking. Sometimes students are impeded by their prior misconceptions and beliefs about music:

> There are a lot of strange assumptions about what music means and about what it means to learn it. It is seen as elitist and sometimes people think it requires innate abilities in order to learn it. Sometimes people have to kind of unlearn this kind of thinking.

Since these students are not only learning to compose but also learning to teach composing, thinking about how and what they are doing, while doing it, is central to the skill set of the course.

The learning goals in the musical composition practice are quite different to those in the *advanced performance* studio. In the studio, the explicit focus is on developing the technical skills required to perform in the student's recital. Alongside this come other skills and abilities, such as developing the stamina to be able to memorise and engage in a physically demanding performance. More implicitly, the studio also teaches the student the mental skills required for their performance. Learning a piece of music is not just in the hands, it is also a cognitive process of understanding the structure of a piece of music, thinking about it, and recognising where you are within that structure at any given time. In the studio, the student doesn't just learn to behave like a musician but to think like a musician. The student needs to have strategies for how they will handle mistakes during the performance in order to "not fall apart completely", Gwen says. "You can help the student prepare for this mentally".

SPOTLIGHT 3.2.B – LEARNING TO DESIGN IT SYSTEM ARCHITECTURE

Although Cécile's IT system architecture course was an advanced one, many students had not been previously exposed to the ideas and concepts of the field. The course therefore introduced key ideas like the range of functions present in even relatively simple architectures, the different ways in which a system can be modelled, and how to use these models to identify flaws or to determine how to implement new functionalities in the system.

Designing an architecture to solve a problem for a client that will work in the specifics of that client's situation can be thought of as involving a number of steps: first deep understanding of the client's situation and needs (analysis phase), imagining possible solutions (divergent design phase), choosing an approach, and then refining it (convergent design phase). It was important for students to identify where they were in the design process and what was expected in that phase: "Some students did poorly because of a lack of depth in the analysis phase. They didn't see it as important: maybe it was seen as boring compared to the exciting work of designing something", says Cécile.

In each of these phases students could draw on specific approaches and tools of the field. The challenge for students was to understand and be able to use these techniques, but also to be able to understand at what stage and in which context particular techniques and tools could be used. "It was a complex course", Cécile says:

> I really enjoyed how applied it was, that the students learned and used real-world skills. Students had to learn content, how to follow a design process, how to work with each other, they had to practice using a whole series of different tools but also understand when and where to use them.

SPOTLIGHT 3.3.B – LEARNING TO MANAGE OPEN-ENDED PROJECTS

Although the content of Roland's course focuses on learning sciences, the goal of the project itself is to teach students how to use what they had learned to frame, to understand, and to solve an ill-defined problem. Roland says,

> The students take the course because they are interested in how they themselves learn and how they can help other people learn, but I am really explicit with them that the particular problem that they will solve in their project is a problem they will probably never face again in their professional lives. So while they may or may not find it interesting to solve this particular problem, what is more important is that they learn skills in problem solving that they can use to solve other problems.

Many of the *problems* students have encountered in their studies up to this point are very well-defined: the students are given an exercise statement which contains all the information they need to solve the problem, and there is usually only one or a few correct answers. At the end, students will know that they got the answer either right or wrong. "Mostly the problems they will face in real-life are not well-defined", Roland continues.

> Often the problem itself is not clear, they don't have all the information they need, and there are a range of things they need to take into account like resources, ethics, legal constraints and so on. So the first task for them is learning to take an ill-defined problem and turn it into a problem they can solve. This is a major challenge for some students.

Some students immediately imagine a solution to a problem and set about building that solution. Often when they build it, it can't be used because it needs too much maintenance, or is too fragile, or too expensive, or because the problem it solves is not the one that their client actually has. Those who take the time to understand the client's needs, resources, and constraints will generally produce more successful solutions. Similar problems can occur for those who work on research projects: many groups imagine a research study which can't be operationalised because it would take too long, cost too much, use data in unethical or illegal ways, or because participants can't be recruited. Roland says,

> They often have unrealistic ideas as to what is possible in social science research – they find it to be messy and unpredictable. Because the results are rarely as neat as in a textbook they sometimes struggle to interpret what the data actually means.

Students work in teams of three or four to solve the problem, and these teams are chosen to be heterogeneous. "I try to make sure that students in each group come from different departments, and that students who did their undergraduate studies elsewhere are mixed with those who did their bachelor degree here", says Roland. The goal, again, is to enable students to learn things that they will be able to use thereafter. Since their professional life as engineers will see students interacting with clients, with other professionals, and with those who will use the products and processes they design, learning to work effectively with diverse people is a useful professional skill.

SPOTLIGHT 3.4.B – CARRYING OUT SCIENTIFIC INVESTIGATIONS IN A LAB

Anne-Sophie's labs address a range of different skills that students need to develop, including

> manipulations and equipment handling, using software to analyse data, and communicating results effectively. But ultimately it is like the training from a PhD – you need to be able to transfer what you learned, the ways of working and thinking in the lab, into different contexts which require analysis and innovative thinking.

In addition to the specific tasks that students learn to perform in any given lab session, there are also skills that are transversal across the whole course: these include learning to work safely in a lab and to link the concepts seen in lectures to the experimental procedures they are enacting. At a deeper level, students are also learning to determine if the experiment was successful or not, how to adapt the experimental design to be more precise, and how to present their results such that they are clear to others.

PROBLEM SOLVING

On one level it is clear that the learning goals in these courses are radically divergent. While Anne-Sophie wants students to learn to apply chemistry knowledge and use software, Cécile is focused on her students learning techniques in IT system design, while Gwen is teaching the physical and mental skills required to perform challenging pieces of music in public.

And yet, at the same time, some common patterns emerge. Roland, Gwen, and Cécile, each in their own way, are concerned with making explicit for students a process which they will use to solve a problem in their discipline. While the problems are as different as composing a piece of music and designing an IT system architecture, the idea that there is a process for solving problems of this type is shared across these different examples of practical learning. Indeed, there are even some similarities between the different processes: in Gwen's case students start by investigating the world through exploring found sounds. In Roland's case too, students also explore the problem space they are presented with and work to understand the goals, constraints, and resources which are in front of them. Cécile's case also involves the student in first analysing the client's situation and needs before turning to designing solutions. These similarities are not coincidental: as Spotlight 2.2 explored, studies of problem solving in a range of different domains suggest that there is often a common underlying process to problem solving which involves:

- understanding, reviewing, or analysing the problem and its context,
- laying out or designing an approach for solving the problem,
- building or applying the solution,
- evaluating or reviewing the effectiveness of that solution.

The idea that problem solving can be represented in terms of these stages is one that is found in disciplines as diverse as mathematics (where the Stanford mathematician George Polya described problem solving as following the stages of *understanding-planning-solving-looking back* [1945/1957]), engineering design (which is often described in terms of *scoping-planning-designing-testing-deploying*), and social studies (where the action research cycle of *review-plan-implement-evaluate* is widely used as a model). Listing these steps is not intended simply as a description of how people *do* solve problems in these domains. A key idea underlying these descriptions of problem solving is that students will be better able to solve problems if teachers make explicit to them that there is a process and if they are explicitly taught the skills and approaches relevant at each stage in the process. Again, there is good evidence to support this idea: a statistical review of studies of learning carried out by the educational researcher John Hattie found that explicitly teaching students problem-solving processes was far more successful an educational strategy than the more traditional strategy of expecting them to implicitly see the how to solve problems by simply solving lots of problems (2009, 210). As both Cécile and Roland note, for example, students who fail to understand or analyse their context adequately typically perform less well than those who do.

Disciplinary inquiry

A second common feature across the learning goals of these case studies is the idea that students are learning the investigatory techniques of their discipline. For Anne-Sophie, for example, students are not simply learning to use chemistry lab equipment but also learning how to investigate phenomena using that equipment, to frame or adapt experimental designs, to analyse their results using software, to determine if the experiment was successful or not, to draw conclusions, and to present their results findings such that they are clear to others. For Roland too, students are learning to design ethical and valid sociological and psychological studies which draw on the approaches and statistical techniques of these disciplines. While the statistical techniques and analyses are different, designing effective studies which can isolate the desired focus of attention, collecting data, interpreting it, and drawing conclusions are equally important here.

Just as with problem solving, carrying out investigations can be thought of as a stepwise process (although, just as with problem solving, the process is rarely linear in reality). Although these stages are given a range of names by different writers, broadly speaking they include the following (Pedaste et al. 2015):

- an *Orientation* stage where the question to be addressed is identified and clarified,
- a *Conceptualisation* stage where general questions are turned into a study design and where concepts and ideas are operationalised in ways that can be investigated quantitatively or qualitatively,

- an *Investigation* stage where data is collected, recorded, and where decisions are taken to ensure the validity and applicability of the study,
- an *Analysis* or *Conclusion* stage where conclusions and inferences are drawn from the data recorded,
- a *Communication* or *Discussion* stage where findings are framed (often in writing) so they can be communicated, and where the limitations of the study are explored.

As with problem solving, an awareness of where one is in the investigation process can help to clarify the different skills to be learned as well as helping students (and their teachers) decide what questions need to be addressed and when.

PROFESSIONAL SKILLS

A third common theme that emerges from these teaching Spotlights is that students learn professional skills. These skills might include managing a project, making team decisions, or managing resource constraints. In the Spotlight teaching situations above, there are numerous examples of students learning the professional skills of working effectively with other people. For many higher education students, their traditional courses are designed to be quite solitary activities – while they are in class alongside others and may study with them, they are assessed essentially as individuals and their performance is not dependent upon others. Practical work is often organised quite differently: for Gwen, students learn a range of social and interpersonal skills in the composition class including skills in cooperating with others, patience, negotiation, empathy, and leadership. While these are described as *extra-musical* skills, she also makes explicit that these are not simply *nice to have* optional extras: being able to work and perform in an ensemble is a key requirement for musicians. Roland also highlights the extent to which taking account of others is a professional skill, both in the sense that students have to learn how to work alongside others in teams composed of diverse people, but also in the sense that they have to be able to take into account the needs and rights of other people who are not in their immediate social environment, that is, people like clients, research participants, or those who will use the products they make.

As with problem solving and investigating, it is sometimes assumed that students will learn to work in teams simply by having the experience of working in teams. Research on student teams, for example, has found that they are often challenging and frustrating for students (Isaac and Tormey 2015) and that students struggle with questions of leadership, conflict, managing egos, and in dealing with *free-riders* or *slackers* (Colbeck et al. 2000). Ford and Morice identify that, for "students already struggling with the pressures of university life in general, the added burden of trying to work within a seemingly dysfunctional team was often the *last straw*" (2003, 269). Research on what happens within diverse teams suggests that experiences in groups can be influenced by social factors such as gender or ethnicity, as well as by discipline: research on speech dynamics within small groups, for example, has found that engineering students tended to be harsher in their judgement of female-typical speech acts when compared to non-engineering students (Wolfe and Powell 2009), while Prisca Aeby and colleagues (2019) found that male students were significantly more likely than female students to report that they were confident that their opinions or suggestions about a project would be valued as much as anyone else's in the group. It is not all that surprising, then, that Carol Colbeck and colleagues concluded that without "faculty guidance, it seemed that only a few student teams developed positive goal or role interdependence" (2000, 78). It is not enough to put students in teams; teachers also need to be explicit about the way functioning teams should operate and about the interpersonal skills required for effective teamwork.

LEARNING TO THINK AND TO MANAGE THEIR THINKING

A fourth pattern that emerges from the case studies is that practical learning often involves students learning to manage their own thinking and learning process. For Gwen, students often brought with them problematic prior knowledge and assumptions (linked to their knowledge of music composed by other people), which caused them to short-circuit the composing process and as a result to produce less optimal work. Being able to identify their own problematic beliefs and to work on changing them is central to becoming successful. Gwen also described how during musical performances, students can lose focus and, if they got lost in a piece of music, could *fall apart completely*. Having the mental skills to recognise and manage that situation is part of what they need to learn in their performance studio. Like Gwen, Roland and Cécile also identify students short-circuiting the process, whether that means investing less in the analysis stage of an IT architecture design project or following their initial intuition as to how to design an experiment without adequately considering the goals, constraints, and resources. Students who can recognise this problematic thought pattern can take a step back and manage their own thinking processes to ensure that they can learn and perform more effectively. But this is not something that happens spontaneously without help.

This ability to think about and to plan, monitor, debug, and evaluate one's own thinking or learning was referred to in Chapter 2 and is known as metacognition. Metacognition has been defined as "knowledge about the nature of people as cognisers, about the nature of different cognitive tasks, and about possible strategies that can be applied to the solution of different tasks" (Flavell 1999, 21). Metacognition can be thought of as a kind of internal conversation in which students ask themselves questions like *What is my goal?*, *How do I know if I am doing well in achieving that goal?*, *What resources do I have to help me?*, *What sort of strategies or practices are likely to work?*, *Is my strategy working?*, *How could I do things differently?*, and *How well did I do?* Metacognition is something that can be learned. Marcel Veenman (2011, 247) has identified three principles which underpin effective teaching of metacognitive skills. They are:

- Explicit or informed instruction: learners should know that they are trying to develop metacognitive skills, and that these skills are likely to help them perform better.
- Embedded instruction: metacognition should not be taught as a stand-alone activity but intrinsically integrated into the ways of doing and thinking in the students' discipline.
- Prolonged instruction: students will not learn metacognitive skills through a one-time intervention, but rather through having repeated exposure over time which will allow them to develop the ability to use these skills fluently and smoothly.

Experiential learning provides just such an opportunity for students to learn to manage their own thinking in ways that are explicitly linked to their discipline.

Thus far, this chapter has looked at the organisation of practical learning as well as its learning goals. Alongside the disciplinary knowledge and skills of music, chemistry, computer science, psychology, and sociology, the Spotlights suggest that practical learning also has other (often implicit) goals. These include:

1. being able to use things you have learned in higher education when you are outside higher education (the problem of *transfer*),

2. finding solutions to problems which are complex and for which a solution is not already known (*problem solving*),
3. using the skills and approaches of their discipline to find out things about the world (*investigating*),
4. professional skills like managing a project or working effectively alongside others (for example, *working in heterogeneous teams*),
5. managing one's own thinking and learning to be able to respond to novel situations and challenges (*metacognition*).

The next section considers effective strategies for teaching these, often implicit, skills in practical settings.

TEACHING IN HANDS-ON SETTINGS

In this final section, our focus shifts from what students need to learn, to how teachers set about teaching the skills and competences of practical learning. The continuation of the case studies below illustrates how teachers' instructional choices reflect the target skills of each practical setting.

SPOTLIGHT 3.1.C – LEARNING IN THE MUSIC STUDIO

Both of Gwen's practical music courses are organised so that students are centrally engaged in making music. Beyond that, however, since the goals of learning are so different, the methods of teaching are also different. While both of them rely on students actually producing music, the musical composition course relies heavily on group interaction and reflection. Students work together to generate and test ideas and sounds, and discuss with each other what they are doing and why. They are asked to think about their role in the group and their contribution to the process of composition. They regularly reflect on what they would do differently if they had to do the same process again. Working together, they identify the musical and extra-musical skills they have learned. And they reflect on how to apply what they have learned to the primary classroom, and how to integrate it with other art subjects addressed in the school curriculum.

Since the process is so central to the learning, students are assessed continuously, and their end of semester performance is not assessed. Students do, however, still take the performance very seriously – the sense of camaraderie in their group means that they do not want to let each other down. But the decision not to evaluate the final performance means that students are not solely focused on the performance and thus are free to pay attention to the process.

Part of that process means focusing on improving their own skills in composition and performance. Students are encouraged to record their performances during the term and to review them in order to make decisions on how to improve. Gwen says,

> Once they start working in groups, my role becomes that of facilitator. My job is to debrief with them about what they did and about what they learned from that. I'm continually assessing their work and giving them feedback within the class.

If the group is central to teaching and learning in the musical composition practical, the advanced performance studio is focused on the relationship between the teacher and the student.

> Historically, the *conservatoire* model was very top-down with a lot of inscribed authority on the role of the teacher. The teacher was the master and the student was the apprentice, and the student was there to learn to play in the way the master played, to mirror and hone the master's technique,

Gwen says. Even if this has changed, the teacher still retains considerable power in the relationship since it is the teacher who determines what the student needs to know and so, it is the teacher who decides what the student needs to do to learn these things. If a student needs to work on stamina, for example, the teacher will select appropriate exercises and instruct the student to work on them. Within this, feedback remains as crucial in this setting as in the musical composition class. Students need to know what they need to do, how close they are to doing it, and how to close the gap.

As well as modelling and giving feedback on technique, the teacher also focuses on the mental dimensions and demands of performance. Talking to the student about cognitively understanding the structure of a piece, locating *hooking points* to help them pick back up if they have a problem, and so on. Discussion and explaining are therefore also important in the pedagogy of the performance studio.

SPOTLIGHT 3.2.C – LEARNING TO DESIGN IT SYSTEM ARCHITECTURE

In Cécile's course, the exercises that students complete were designed to walk them through the different stages of the design process and the kinds of tools and approaches they could use at each stage in the process. While this approach gave them both an overview of the design process as well as drilling down to specific tools and competences, not all students found it easy to zoom out and see how it all fitted together. Cécile says,

> For example, when learning a particular approach to representing a system, students could follow a series of steps to completion but not be able to step back and say "Ah! I can now represent a system in this way; I can use that in this situation or in that situation".

SPOTLIGHT 3.3.C – LEARNING TO MANAGE OPEN-ENDED PROJECTS

For Roland, learning in his project is based on students doing and on reflecting on what they have done.

> Students will only learn new things if they try to do new things. A lot of the project is designed to push them outside their comfort zone. Students are assigned to groups, for example, and the groups are chosen to include a mix of disciplines and backgrounds. Some students have never spoken to a client

> before, or recruited participants for an experiment. The conditions for learning are created by asking them to do things which are new to them.

This gives rise to a lot of student questions, which Roland says, he tries not to answer.

> One year a team came to me with two different designs and explained they could not choose between them so they asked me which they should pursue. I asked them why they couldn't decide. After a while, it became apparent that they didn't know any strategies that could help them make a decision. I explained two strategies to them, a decision matrix and multi-voting. I suggested they use a strategy and come back to me to let me know what they decided. I think they would have preferred if I had just told them which design was better, but I don't think they would have learned much from that.

Alongside their final report students also complete a learning portfolio documenting the process of doing the project which accounts for 20% of the marks. At set times during the term, they are asked to collect data on how they are managing their project and on how they are working as a team. Each team has to analyse this data and make suggestions as to how they could work more effectively. At the end of the semester each person lists all the changes that their group had proposed, which ones actually got adopted, and which ones they would try to use in future team projects. The portfolio activities shift the focus a little away from the product and towards understanding the process.

> They'll probably never have to solve this same problem ever again, so the solution they arrive at isn't all that important to them. But understanding the process is. Even if their solution doesn't work, I'm not going to worry, so long as they understand why it didn't work and how they could manage the process better next time.

SPOTLIGHT 3.4.C – CARRYING OUT SCIENTIFIC INVESTIGATIONS IN A LAB

Developing independence in the lab is important for Anne-Sophie,

> Our graduates aren't employed to just follow protocols – they need to be able to tackle novel problems and figure out how to design experiments that meet specific needs. To develop this ability, students need to have the experience of making decisions.

However, Anne-Sophie also has to manage significant logistic and safety concerns related to having hundreds of novice chemists in the lab each week.

> I want students to feel that they are making the decisions, that they have to figure out what needs to be done and how to do it. But in fact, I have set up sort of a corridor for them, even though their decisions make them zigzag along rather than running straight through. For example, students might be told they can synthesis a particular product any way that they choose. But once students have narrowed their options in terms of the chemicals I've made available to them, they will end up with one relatively safe option. There is a lot of guidance that they don't really see.

As with other aspects of practical learning treated above, it is evident that there is a great deal of differences between the teaching approaches. In some cases, like Gwen's performance studio, the teacher is highly directive. In this case, the teacher is demonstrating and directing and the student is an apprentice, mirroring and *learning from the master*. In Roland and Anne-Sophie's cases, the course activities are designed to build the learner's autonomy and ability to deal with uncertainty. To achieve this, the teaching is organised so that the student is much more in control. Indeed, even when the students ask for direction, Roland sometimes tries to avoid giving it to them, preferring instead to nudge them into making their own decisions. Cécile's situation is somewhat between these two: students are working on their own project and have to make their own decisions, but they also have the teacher's input both in the form of lectures and in the form of highly structured exercises which *walk them through* the processes they need to master.

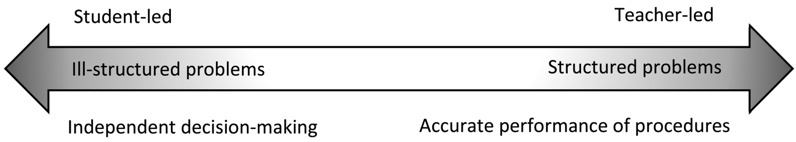

FIGURE 3.1 Who directs students' activities in experiential classes and with what goals?

Rather than being simply student-led or teacher-led, then, experiential learning can be thought of as being along a continuum ranging between those two positions. This continuum is illustrated in Figure 3.1. This is not simply a function of the teacher's preferences or personality. For example, Gwen's two practical courses have very different organisational approaches to learning activities: her composition studio is substantially student-led, and her role there is often that of facilitator, while in the performance studio her role is more that of master who leads the student-apprentice. More important than teacher personality or preference are the learning goals which ultimately determine whether the teacher is modelling, explaining and directing, or facilitating.

EXPLAINING, QUESTIONING, GIVING FEEDBACK, AND MANAGING THE LEARNING CLIMATE

Underneath this divergence in the *big-picture* organisation of the practical class, some patterns stand out. In all cases there are times when the teacher needs to demonstrate or explain to the students. In some cases, like Cécile's course, this may be seen in pre-planned and highly structured explanations in the form of lectures and solved exercises to accompany a project. In Roland's case the explanations are not pre-planned but rather arise in response to students' questions. In this case, even if Roland doesn't want to explain to students which design is better, he still needs to explain to them different strategies which they could use for making their own decision. *Effective teacher explanations* are, then, central to practical learning.

A second strategy which emerges is *asking questions or posing problems* for students. When Roland is asked a question by students, he responds with a question. For Anne-Sophie, labs are structured so as to avoid giving all the answers to students – their instructions are deliberately structured to include gaps which the students themselves have to fill. Students' processing of information is central to their learning; she says, "If they just replicate the procedure, they aren't thinking and they forget everything quickly. They need to be thinking, to be making connections to the theory, and checking to see if it makes sense". Being able to formulate appropriate questions or thinking tasks – often in response to student questions – is central to practical teaching.

A third teaching strategy that is evident in multiple case studies is that of *giving students feedback* on the work they produce. For Gwen, for example, her teaching approach is described as "continually assessing their work and giving them feedback within the class". Since feedback means responding to something a student has produced, and since practical work is centrally concerned with students producing something, feedback is an absolutely central teaching activity in labs, fieldwork, projects, and studios.

Finally, it is clear that in all these cases, students are being asked to try things they are not comfortable with, to fail, to get feedback, and to improve. Students are only willing and able to do this if the class climate is one that makes them feel secure and where they think that the teacher is genuinely concerned with their learning. Managing the learning climate of the class is, therefore, a fourth important strategy.

Chapters 4–7 of this book are structured around these four strategies. Whatever the learning goals, being able to explain, give feedback, ask good questions, and manage learning relationships are teaching strategies that can be used to help achieve these goals.

DOING, REFLECTING, THEORISING, AND TESTING

It is obvious that practical courses typically involve the student in *doing*. However what the Spotlights above also clarify is that *reflecting on doing* is central to learning in experiential courses. For Gwen, students work together to generate and test ideas and sounds; then they discuss together (i) what they are doing and why, (ii) how they are working together and how they would work together differently if they had to do a similar task again, and (iii) how to apply what they have learned to the primary classroom. For Roland too, students are asked to reflect as part of a portfolio which they develop alongside working on their project. In this case, students collect data on their own processes and decide what they would like to change in how they are working. As with Gwen's case, they discuss these reflections with teammates.

One frequently used way of thinking about the relationship between *doing* and *reflecting* in practical learning is the experiential learning cycle model, originally proposed by David Kolb (1984).

For Kolb, "Learning is the process whereby knowledge is created through the transformation of experience" (1984, 38). In order to learn then, students need four different kinds of abilities to transform experience into knowledge:

- concrete experience abilities: to be able to be open to fully experience, without bias, their actual experience,
- reflective observation abilities: to be able to observe this experience and to think about it from different perspectives,
- abstract conceptualisation abilities: to be able to see regularities in these experiences and to link them to logically sound concepts and theories,
- active experimentation abilities: to be able to use these concepts and theories to make decisions and solve problems in the real world.

These four abilities are represented graphically in Figure 3.2.

Kolb identified that, for learning to take place, it is not sufficient for a learner to employ only one of these abilities – rather experiential learning needs to be understood as a holistic and cyclical process in which learners can draw on all of the required learning abilities one after another. In this way, students cycle through a series of steps: having an experience, thinking about it, using that to build their concepts and understandings, and using those concepts to solve problems and ask questions of the world.

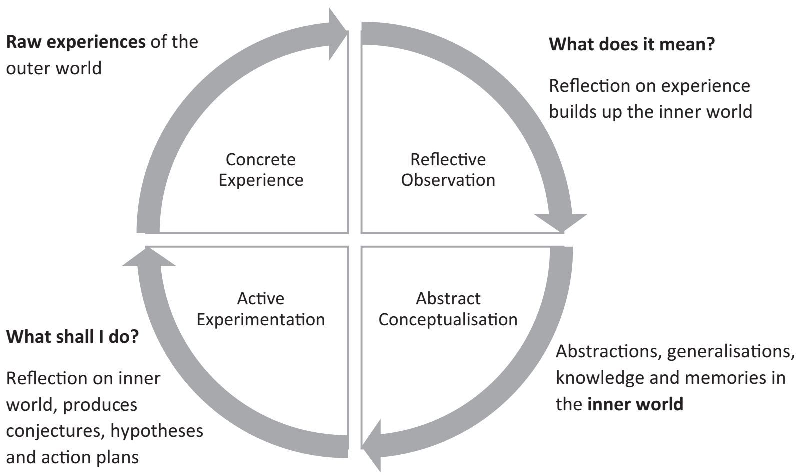

FIGURE 3.2 Kolb's experiential learning cycle (1984)

(Adapted from Exley et al. 2018, 17)

Kolb's ideas have been hugely influential. Later work has simplified his language a little to suggest that the four skills of experiential learning can be framed as four stages which can be called *experience*, *reflect*, *generalise*, and *test*. It may not be necessary for a learner to follow this particular order, though they are often presented as four sequential steps.

Mick Healey and Alan Jenkins (2000) describe the application of Kolb's ideas to a range of different geography courses, including a fieldwork course. In their case, before the field experience, students began by reading competing theories regarding the geography of post-industrial society (AC – generalise) and then worked in teams to define how they would collect interview data from the field study which would allow them to test these models (AE – test). Once in the field, students went through a cycle of conducting initial field interviews (CE – experience), discussing them and journal writing (RO – reflect), making tentative hypotheses based upon their interviews and reflections (AC), adapting their interview schedule in light of their emerging theorisations (AE), and then carrying out further interviews (CE).

They note that Kolb's learning cycle provided a useful way to think about the sequence and structure of the activities that they built into the course in order to maximise student learning. They also note that the model typically does not require a complete revision of existing hands-on activities – it is a useful framework for thinking about and tweaking practical classes, rather than one which requires massive restructuring of them.

It is worth noting that, although Kolb's work has also been extended into a highly influential *learning styles* model, this idea is not explored in this chapter. Although *learning styles* theories are very popular they are also highly controversial among learning researchers. Indeed they may constitute an example of what is sometimes called pop psychology or *neuromyths*, that is, ideas about the brain and the mind which have been so widely shared that they become popularly accepted despite a lack of evidence to support them. In the case of learning styles, there is actually little empirical evidence to support the idea in general (Pashler et al. 2009) or Kolb's learning styles approach in particular (see [Coffield et al. 2004, 60–70] for a review). We present Kolb's experiential learning cycle solely as a useful way to think about practical learning and do not promote linking it to learning styles.

This section began with a recognition that doing alone was not sufficient for learning – it seems likely that students will need to engage in a mix of doing and reflecting (as well as generalising and testing). However, it is worth noting that, although the term *reflection* is widely used, it is not always evident to students what they are expected to actually do when being asked to reflect (indeed, as we will return to in Chapter 10, the same can often be said of higher education teachers). Writing in the context of students' field experiences in a teacher education programme, for example, Oliver McGarr and Orla McCormack (2014) note that, while the term *reflection* is so widespread that it has effectively become a dominant paradigm in teacher education, many students do not seem to have a clear idea as to what they are expected to do when reflecting. Students typically use reflection as a kind of diary (recording day-to-day events), or as a form of confession (avowing responsibility), but rarely as a form of critical inquiry into their own practices and those of others. They note a number of factors which may enable students to engage in the kinds of deep reflection which would be associated with learning:

- The timing of reflective activities is likely to be important: reflection involves "detachment from an activity followed by a distinct period of contemplation" (Hatton and Smith 1995, 34). Reflections may therefore require some time to detach and pause for thought.
- Treating reflection as a dialogue: when people discuss their impressions with others, it often becomes apparent that the way they interpreted a situation is not the same as how others interpreted it. As such, they start to see their own perspective as being just that – *their own* perspective, and one of *potentially many* perspectives. As such, they move from "this is how it was" to "this is how I saw it". This, in turn, opens up the possibility to reinterpret or rethink the situation. Building opportunities for dialogue is likely to be important in supporting reflection.
- The intended audience is likely to be important: McGarr and McCormack note that students seem to sometimes write reflections as if they are following a distinct narrative in which they demonstrate their perseverance and commitment by overcoming obstacles. They suggest that, in writing in this way, the student may be performing to a script which matches what they think the tutor wants to see. If the students are to be given space to be more honest in their reflections, perhaps at least some of those reflections need to be for their own eyes only.

You may want to apply these ideas to reflecting on your own experiences. This is why, in Chapter 2, we suggested that you may wish to set aside time to work through the Reflection point activities, to write down your answers, and to discuss them with colleagues.

THE IMPORTANCE OF CLEAR LEARNING GOALS

One final key pedagogical dimension is implicit in much of the discussion in this chapter: for problem solving, investigations, professional skills like teamwork, and metacognitive competences, it was pointed out that students learn these skills best when the skills are made explicit to students.

This is an important point, because it is sometimes assumed that if one creates opportunities for students to have practical experiences, then they will learn from those experiences. This approach is sometimes referred to as *discovery learning* (but could be more precisely called *unguided discovery learning*). Discovery learning is often characterised as encouraging students to explore a given situation with minimal guidance with the assumption that students will learn by having their curiosity unleashed and spontaneously recognising patterns (such as that particular ways of working in a team are effective and others are not).

A commonly used analogy is the idea that infants can learn to swim simply by being immersed in water and allowing their natural reflexes to take over. While infants have reflexes that sometimes make it look like they can naturally swim, the reality is that infants cannot *naturally* swim: indeed, drowning is a leading cause of death among young children. Similarly, it is not realistic to expect that a natural curiosity and an innate ability to recognise patterns will mean that students are able to learn to solve problems, or to manage teams simply by being dropped into a team and asked to solve problems.

This is not simply a question of philosophy or of competing educational theories: this issue has been subject to exhaustive research over an extended period of time. In their review of quantitative studies of learning, John Hattie and Gregory Donoghue (2016) found that making the success criteria or learning goals explicit to students increased their average attainment very substantially. Hattie and Donoghue note that,

> when students learn how to gain an overall picture of what is to be learnt, have an understanding of the success criteria for the lessons to come and are somewhat clear at the outset about what it means to master the lessons, then their subsequent learning is maximised.
>
> (2016, 6)

CONCLUSION

This chapter looked at a range of practical work settings in higher education including a chemistry lab, a music studio, geography fieldwork, a research project, a teacher education field experience, and computer science and education projects. The diversity of organisation, of learning goals, and of teaching strategies across these different forms of practical work is evident. At the same time, it is clear that there is a high degree of commonality shared across these practical learning settings. While practical courses are central to teaching students the knowledge and skills of their discipline, they also generally share a focus on certain underpinning *ways of thinking*. These ways of thinking include:

1. being able to transfer what has been learned in their course, project, or lab into real-world contexts,
2. carrying out investigations using the skills, approaches, and tools of the discipline,
3. solving problems which are often ill-defined or open-ended,
4. working as professionals, including interacting professionally with others,
5. being metacognitive – that is, managing one's own learning and thinking in order to be able to adapt as situations change.

Because the goals are so varied, the ways of teaching in experiential settings are also varied. But, once more, there are some underlying similarities across these learning settings. Central to practical learning is Kolb's idea that "Learning is the process whereby knowledge is created through the transformation of experience" (1984, 38); in other words, it is not enough for students to *have* experiences in practical classes, they also have to *transform* that experience into concepts and ideas by reflecting on and discussing the experience. Their classmates, labmates, and project team members are central to this in that they can provide a space for exchange and discussion. But so too are teachers, who will:

- *explain* ideas to students that help them to make sense of their experience,
- *pose challenges* and ask questions of students that will encourage them to think through their experience,
- *clarify goals for and give feedback to* students which will help them understand what they are aiming to achieve and how they can achieve it,
- *create a class environment* that supports students to engage in the various activities identified above that contribute to learning.

These four ideas are addressed in each of the chapters in Part II of this book.

FURTHER READING

This small number of sources is intended to provide further useful information for those who wish to explore the chapter topic in more detail. A full reference list for the chapter is provided below.

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University of Waterloo's Centre for Teaching Excellence also has a valuable website: https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/metacognitive.

Vanderbilt University's Centre for Teaching has a useful website on teaching metacognition. https://cft.vanderbilt.edu/guides-sub-pages/metacognition/.

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