

Engineering skills and learning routes

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ABOUT

This text was written from the work and reflections of Jacqueline Bergeron from her cognitive psychological approach combined with the science of education, and through contributions to her PSDR research project (in Auvergne) she led by a research team from AgroParisTech.

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Since the late 1980s, the competency approach is necessary in many conceptual approaches to training, whether initial or continuous, higher or professional. It is particularly taken for reference in curriculum development, awarding of degrees by VAE (Validation of the Acquisition of Experience), creation of fruitful learning routes. It also serves as a lever for monitoring and developing professional projects.

The polysemy of the concept shows both its intensity and complexity. If it seems impossible (and probably undesirable) to currently reach a consensus to define skill, insights from different authors, especially [Leboterf](#), [Zarifian](#), [Wittorski](#), [Malglaive](#) allow us to come up with what appears to characterize this concept as a series of effective actions, responding to a family situation. That is, the actions that the person is managing to control because he has both the necessary knowledge and ability to mobilize his knowledge for the right purpose, in a timely manner and as appropriate to his environment, to identify and resolve situational problems.

So there is a set of activities that a person organizes to produce an accurate and efficient result. Skill actually fulfils the possible knowledge transfer through an appropriate answer, at the theoretical, technical, and relationship levels to a situational problem.

The competency model is generally based on two main designs : the first behavioural type, the second social constructivist. The latter seems more illuminating than the previous one in the current context for lifelong training, because firstly, it is striving to reflect the complexity of the activity in the workplace, and secondly, it is focusing on supporting the individual; the fundamental concept as part of individual journeys that follow within the increasingly diversified learning environments and outside the formal scope of training.

The social constructivist approach thus forms a link with the professional teaching that identifies the task ahead (the prescribed work) of the activity (the actual work), and thus the epistemic registry of the practical knowledge registry. This is between the cognitive model and the operational model to better identify the [zone of proximal development](#) ([Vygotski](#)), in which skills are built by and through situations.

The social constructivist approach therefore assumes that the entry of skills, involves an entry by persons and not by the activities : if there still exists knowledge (from a variety of sources) « under » a skill, we now know that it is not sufficient to « do » and that the « skill », does not allow the « knowing-how-to-do » as it makes its way forwards, in an unrepeatable, original and unique manner by each active subject. So the skill never reduces to theoretical or procedural knowledge codified and learned as rules, even if they are essential.

To illustrate, insights from few authors previously cited

To define the skill, Gérard Malgaive (1998) describes the theoretical knowledge, skills, expertise.

He says theoretical knowledge bears no direct operational relationship to the practice. For him, the only practical effect of theoretical knowledge is to know and not to do, to say what is and not what should be. Therefore, the theoretical knowledge does not indicate the purpose that must continue to make efforts, nor does it set itself the means to achieve it. However, it allows adjusting very precisely the practical interventions on the real world, anticipating their impact, their success or their failure. Theoretical knowledge is the basis for the effectiveness of knowledge that regulates the action known as procedural knowledge.

Expertise always encompasses (and increasingly) diverse realities. It has intersections with the theoretical knowledge and procedural knowledge, which are at the interface between the concepts and operational elements that allow appropriate action in a given situation.

Malgaive indicates that the know-how may designate unique gestures of a practice, what Anglo-Saxons call « skill », a term that can be translated as skill. In this context, the know-how allows not only to produce acts, but also to do so with skill and endurance (the knack). This endurance or skill falls within the internalized knowledge that has become automatic to the person who plays. It is therefore difficult to self-evaluate one's skills, but a work on the analysis of professional practices, an effort of reflexivity can gradually provide support, build a mapping of skills.

Skills are thus human acts available to be learned and experienced formally (at training courses), informally (excluding training device) or non-formally (through experimentation that helps build experience).

They come in a unique way linking the two transformations:

- a) Transforming object (the person playing)
- b) Transformed object (solving a situational problem)

The knowledge can therefore be located, they have a beginning and an end, and they have a path that can be identified in the skill. Malgaive calls this aspect the kinetics of the act. The difficulty in the teaching approach will consist of clearly defining the kinetics within the skill.

Le Boterf (2001) compares the skill with an action of communication, which cannot be understood without reference to the subject that issues it, or the context in which this subject lies. In this context, it is important to understand both the actor and the action (an important point in the teaching engineering approach), i.e. « the enaction » (as the English term to enact, brings about) that underlines the necessity of supporting (to guide) the person in his career-building skills (of whatever kind).

Zarifian says skill is taking initiative and responsibility on the part of the individual on situations with which he is confronted. The word initiative comes from the word initiate : begin something in the world. Taking initiative is an action that modifies the existing, introduces the new, starts something, that creates. Any skill generates an innovative component oriented towards the subject in action.

The word responsibility « guarantee », requires responding to... The competent person responds to initiatives undertaken and their effects, not only in terms of social judgments which will be made on him (or an evaluation system), but also of his sense of responsibility, that is considering his accepting the responsibility of taking charge of the situation that can only be unique. Taking responsibility is thus the counterpart of autonomy and decentralization of decision-making including training systems.

Major « components » of skill

Based on these different interpretative guides and approaches, it is possible to identify the major components of skill : although closely, and uniquely, interlinked by each individual. Identifying them distinctly gives a better understanding of how a person connects to them during his learning process :

- Theoretical knowledge (to understand, to interpret)
- Procedural knowledge (how to do)
- Procedural skills (how to proceed, how to operate)
- Experiential skills (knowing-how-to-do, knowing how to behave)
- Social skills (« being », to behave appropriately)
- Cognitive skills (how to process the information, to reason)

As mentioned before, it is through the original and unique way that each learner interlinks these ingredients, we are able to understand the processing of cognitive transformation operating a workplace situation within environments that necessarily influence the choices and learning methods. We are assuming that this understanding helps to better identify the role of training, which now has the essential function of supporting people in their life-long learning path.

By decomposing to analyse work situations experienced, each component reveals itself in the « photographic » sense of the term. This decomposition cannot overlook the analysis of the stories about work.

This approach requires « de-compartmentalizing » areas of knowledge, which, while being interwoven, are relatively closed. The analysis of work situations by practitioners coupled with a process of reflexivity on its learning strategies thus form the basis on which define what are known as core business skills. This forum for analysis is the ideal place to reveal the different components of the implementation of a work situation, a practice, a profession independent of the work « prescribed » which is merely a representation of the activity, in particular for the high-risk professions or so-called « fuzzy » jobs (Jeannot).

This *awareness raising* of knowledge that has become automatic, leads the individual to break the habitus (as defined by Bourdieu), to get out of an unconscious reproduction of the work allowing him to indicate how he faces the unknown (new situations), how he creates, invents and introduces innovations in his daily practice. Identifying skills is more of a researcher's posture than a technician's posture : this is an analytical process to move from « normal » thinking (the work required) to affected thinking, distorted, fundamentally dialectical and dialogical. This is the so-called teaching support that will initially help the individual identify components of his skill, secondly enable him to organize, combine and adopt them in an objectifiable and transferable approach. We then gradually reach a mapping of skills that can freeze within firmly predefined skill frameworks. Skill is, and remains, an unfinished symphony playing on the colourful sheet music through diverse modes of action, plural environments, themselves as new skills developers.

Teaching engineering, an entry of skills

By focusing on the person, the skills-based approach leads to new repositioning and new developments of teaching engineering by giving prominence to the remarkable activity of the subject. Consequently, we build individual routes, customized training (sometimes called professionalization routes). The subject plays an active role in the shaping supported by its resources that transform, reform, develop and capitalize within a formative area.

The approach to training in terms of skills thus involves teachers identifying and characterizing the specific situations facing trainees, students : these situations are the levers facilitators of knowledge transfer. Teaching engineering is thus based on the analysis of the activity to rebuild its conceptual structure and identify a number of formative situations targeting (meaning the target) skills.

It is fair to assume that the workplace that includes many informal and non-formal learning environments is a space to build, develop and restructure skills of the subject in action.

This implies that new learning engineering is introduced within an alternating space « work-training » where the main actors involved in the formative process (trained-trainers-companies) share the ability to train (in particular, universities and companies).

The new engineering includes some key features in the training design :

- An active role for trainees : they have not only the right to training but are the source of the right and duty to be fully effective in their training and career paths.
- Contextualizing the action of trainees in workplace situations or solving the actual problem situations.
- A learner-teacher repositioning involves a new teaching relationship.
- The introduction of the key concept of support in terms of training, a support towards, by and to managing change in transitional situations faced by the people in their life course. Transmitting knowledge, teachers become a guide helping to understand, organize and build the learning and career paths.

Assisting is becoming a way of developing and integrates into teaching engineering

In this new reconfiguration, the teaching support cannot be taken for granted, it refers to the [complexity](#) (Morin 1977) and needs constant attention to the ethical background ; the major benchmarks for the ethics of support refer to a few key words : skill, respect for persons and their autonomy, justice, responsibility.

The guides are highly skilled and diversified, involving in particular the acceptance of the confrontation, the challenge, the questioning (assessment) of their practices by the learners.

Approaching teaching engineering in terms of support involves moving away from a technical concept of training that long prevailed (and will likely prevail in the future), inscribed in a liberal economist vision, to think the training function as a process of transformation of an individual to support change.

« The accompanying teacher » is not a « guide » or a « tour guide » (although there is the concept of path, career path in training). Secondly, he agrees to assist the other without deciding the path he should take. In that sense, the educational support would be to travel with the trainee while staying in the background, lucid, attentive to his journey. So travelling with the trainee on a path other than his own and with the awareness that the guide is not going, *ultimately*, where the trainee is going. It is in this space of « combined liberty » that the transformation can happen, and, hence, the development of skills through progressive apprehension, in a back and forth movement of different components that constitute them.

In this context, teaching engineering requires constant updating of the intervention methods supporting renewed content.

What the learner needs to build and to develop skills and therefore to learn, is an anthropopedagogical relationship ([Charlot](#)). That is, a relationship of trust and closeness, but at the same time distant in which he exists on an equal level with others. The learner is also a human being who needs support to organize, build and understand the professional world in which he is involved or already registered.

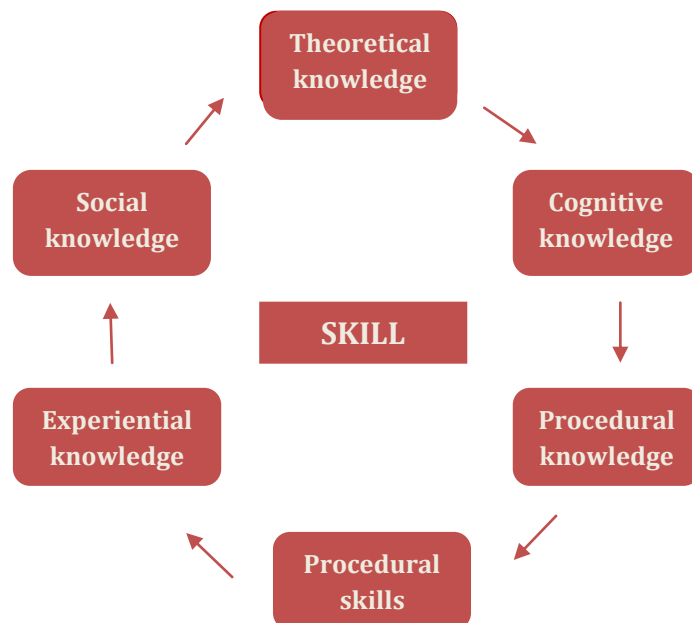
In these new fields of engineering, the role of the teacher is changing : he is no longer merely a transmitter of knowledge, but is refocusing his efforts towards mediating through support, offering the trainee the right to build his own route and his content in cooperation with the teaching staff and depending on his « target » of professionalization. This posture necessarily involves a decentralization of « absolute knowledge ». The direction (direction and meaning) emerges through production of knowledge from the trainee by himself and upon himself within a group.

Developing the skills in learning engineering is not to radically move away from theoretical knowledge but to wonder why particular knowledge is part of the training programme, which is taught, in what order, which the trainee is going to discover by himself, which does not necessarily have its place... More simply, no training content can be proposed without the possibility of explaining their **reliance** on skills, no learning method may be proposed without contributing to supporting change, a vehicle for developing the skills.

Quite the opposite. Training is neither a disparity, nor a revolution but probably a development, in particular teachers evolving in their relationship to knowledge and learning. We cannot enhance the skills without working on complex situations that involve the teacher losing a bit of his fluency in sharing knowledge to venture into an area where he facilitates and organizes learning situations thus increasing the area of uncertainty in which unfolds the teaching activity.

Analysis of basic components of skill

Based on the framework elements outlined above, the components of skill that we have identified supporting the interviews conducted during collaborative work under the [PSDR Research programme Auvergne¹](#), are proposed in the following mapping.



- Theoretical knowledge : understanding, interpretation of issues, knowledge transfer...

- Cognitive knowledge : processing of information, transfer of knowledge elements, reasoning...
- Procedural knowledge : Knowing how to proceed
- Procedural skills : Knowing how to play, to address the problem situation
- Experiential knowledge : playing from work experience
- Social knowledge : attitude towards the task

These 6 benchmarks were used during interviews conducted under this research programme. Interview experience shows that people very often rely on experiential knowledge acquired by different means (mostly at work), in contact with others (colleagues, partners) and through self-study, but also during « extra time » : informal meetings, trips... This knowledge allows both to adapt to workplace situations and to developing his basic skills. We see that learning from experience is generally linked to the motivation of responding to a problem situation or adapting to a workplace situation (this relates to the socioconstructivist learning theories). Social knowledge is discussed in correlation with the experiential knowledge with which it is closely intertwined. Procedural skills are in third place among the knowledge mentioned, they reveal by the way people describe how they play and face a problem situation encountered at work.

Procedural knowledge (knowing how to proceed) are mentioned in the form of procedures to follow : specifications corresponding to the objectives to reach. It is less highlighted than the procedural skills and often appearing as a constraint interfering negatively with the creative working area.

Individuals less expose cognitive knowledge and theoretical knowledge. This does not mean they are not present or needed to play with skills. The difficulty of « raising awareness » of the theoretical knowledge considered part of a cognitive transfer on which relies playing with the skill may partially explain this low mention. It is interesting to note that the mention of theoretical knowledge (formal knowledge) has a rather negative connotation: people tend to reveal weaknesses rather than strengths on which they rely in their work. In return, it is interesting to note that experiential knowledge seems to promote the learning of theoretical knowledge through self-study. This is an invitation to revisit the dialectic relationship between emotional and cognitive that the subject experiences during a learning process.

¹ Research programme *Pour et Sur le Développement Régional* (2007-2011) involving research teams and local actors in the Auvergne region.

The foregoing reading elements show that [informal professional learning](#) (Carre and Charbonnier) occupies a central place in building and developing skills to respond better to situations encountered. Carre and Charbonnier thus define informal professional

learning : « any phenomenon of acquisition and/or of lasting change in the knowledge produced outside the times expressly devoted to training courses introduced and likely to be invested in the professional activity² ». It seems that the specific nature of territories, social, economic, cultural environments, etc. where the work is monitored adds to this trait. It appears difficult in this context (see difficult) to define a well-classified workspace, by stabilized work situations. Inherent in the aspect skills can be stabilized (in the context of their replication in a work situation), and, consequently, the changing activities involve establishing a permanent learning dynamic by individuals. In this context, we are assuming that territories, specifically the various professional, social, cultural activities that develop are a source of building skills and are extraordinary places of learning with parameters still difficult to identify but must necessarily be quickly integrated into the training systems.

This aspect shows a dual necessity : to keep in mind the training provision through a *bottom up* approach that would build on the data from the field to adapt the training content, to design a learning engineering supporting informal learning.

This engineering involves designing training on how to support change exclusively on the traditional model of transfer of knowledge. In light of the working environments, areas of autonomy at work (spaces for developing skills), gaps left vacant by the initial training, spaces for innovation, creativity, initiative, the support built with these informal learning is undoubtedly an essential lever in *learning* development. This implies that learning engineering relies at one end on recognizing a personal approach to learning (by designing unique training routes), at its other end, providing tools (analysis of practices, diverse perspectives on identical situations, self-study...) allowing integrating experiences in the territories as a collective space for learning. We read that people working or facing problem situations long for attention, not necessarily as a response to providing formal knowledge, and needing support in reading the situations encountered.

² Carre Ph. and Charbonnier O., (directed by), (2003), *Les apprentissages professionnels informels*, L'Harmattan, Collection « Savoir et formation », p.20.

These new approaches imply that learning engineering appeals two different attitudes among teachers : total open mindedness on the content, which allows considering formative experiences arising from diverse fields ; directivity on the container, psychological shell and thinking-self ([Anzieu](#)) addressing the need for security, essential

and structuring throughout the learning process to allow managing and tiling mental representations conducive for enhancing skills.

This approach involves a complete reversal in the designing of learning engineering still based today on pre-identified training content, « pre-formatted » within « closed circles » of formal learning institutions.

For this purpose, in professional training, must be carefully distinguished as what are called core business skills « controlling » the dispersal of the most portable, changing and specific skills dealing with the contexts in which the person plays (will play) with his skills, whose contents are constantly changing, transforming, repositioning on changing fields, in continuous transformation.

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