9 | Stimulating adaptive performance through constructively aligned transdisciplinary education and the Peradex assessment approach

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Y. Baggen [1], F. van Rijnsoever [2], L. de Jongh [3]

ABSTRACT In this chapter, we present adaptive performance as a learning outcome of transdisciplinary education via which we can educate students who are capable to help solve grand societal challenges. Based on transfer and a scaffolded approach, we present a constructively-aligned model for transdisciplinary education at the bachelor and master level.

Further, we introduce the performance-based adaptive expertise (Peradex) assessment approach as a valid and reliable formative assessment to monitor students' adaptive expertise development. Adaptive experts can flexibly use their knowledge and skills to respond to new problem situations in creative and innovative ways. Transdisciplinary education – in which students address real, societal issues and co-create innovative solution pathways together with extra-academic stakeholders – opens-up the door towards the design of education in which students are challenged to address societal issues in education and to develop their adaptive expertise.

In such education, students can learn how to navigate uncertainty, empathise with others, and address grand societal challenges in meaningful ways.

At the end of the chapter, we present design considerations with which educators can design transdisciplinary education in such way that students can develop their adaptive expertise and practice adaptive performance. We invite educators to further develop these design considerations and share inspirational practices to inform teaching practice, including the use of the Peradex approach as formative assessment instrument.

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Introduction

Higher education has the responsibility to learn students how to address grand societal challenges (GSCs; Voegtlin et al., 2022). GSCs, such as migration, rethinking proteins, and the transition towards a circular economy are uncertain, complex, and value-laden in nature. These challenges are ill-defined, change over time, and involve different people with different, changing stakes. In higher education we aim to educate students in such way that they are able to navigate the uncertainty inherent in addressing GSCs (Bohm et al., 2025).

Different pedagogical approaches have been introduced in the literature to educate students who are capable to help solve GSCs. Think for instance of community-engaged learning (e.g., Nguyen & Jessen Condry, 2023), challenge-based learning (e.g., Baggen et al., 2024; Van den Beemt et al., 2023), entrepreneurial learning (e.g., Baggen et al., 2022) and change agent pedagogies (Van Rijnsoever et al., 2023). What these approaches have in common, is that they all offer authentic, reflective, collaborative and engaging learning experiences to students. Students learn across disciplinary boundaries (i.e., interdisciplinary learning; Verreijken et al., 2023) and different parts of society (i.e., transdisciplinary learning; McGregor & Volckmann, 2013). In this book chapter, we refer to such approaches as *transdisciplinary education*.

In transdisciplinary education students collaborate across disciplinary and societal boundaries and use new knowledge to realise societal impact (Visscher et al., 2022). Students are challenged to combine different disciplines and perspectives, which encourages them to empathise with others and be sensitive to different problem contexts (Bohm et al., 2024). GSCs are ‘wicked problems’, which are nearly impossible to solve. This requires that students learn to accept the complexity of reality and approach phenomena from multiple disciplines and perspectives.

Given the open character of transdisciplinary education, it is difficult to capture students’ learning in pre-defined learning outcomes (Sluijs et al., 2024), standalone to develop constructively aligned education in which such learning is assessed. In this chapter, we aim to address this challenge and discuss adaptive performance as measurable learning outcome of transdisciplinary education. Adaptive performance is the “visible expression” of adaptive expertise (Pelgrim et al., 2022, p. 1258). Adaptive expertise is the ability to deal with changing situations that develop in new or unusual directions, while building on routine knowledge (Hatano & Iganaki, 1984). It helps individuals to navigate through uncertainty, and to address challenges that are new to them in creative and flexible ways (Bohle Carbonell et al., 2014; Pelgrim et al., 2022; Ward et al., 2018), as adaptive expertise enables them to be efficient and innovative. We argue that transdisciplinary education is a promising learning environment to facilitate the development of adaptive expertise and the practice of adaptive performance of students in the context of addressing GSCs. The uncertain, complex, yet social nature of transdisciplinary education makes it an interesting environment full of learning opportunities to develop adaptive expertise and demonstrate adaptive performance.

More specifically, we elaborate how transdisciplinary education can facilitate adaptive expertise development based on its two main dimensions (i.e., efficiency and innovativeness) and transfer, which is the extent to which one can use previous learnings in new problem situations (Cheung & Kulasegaram, 2022). Further, we present how adaptive expertise can be measured with a reliable, valid instrument, namely the performance-based adaptive expertise assessment approach, which we call the Peradex.

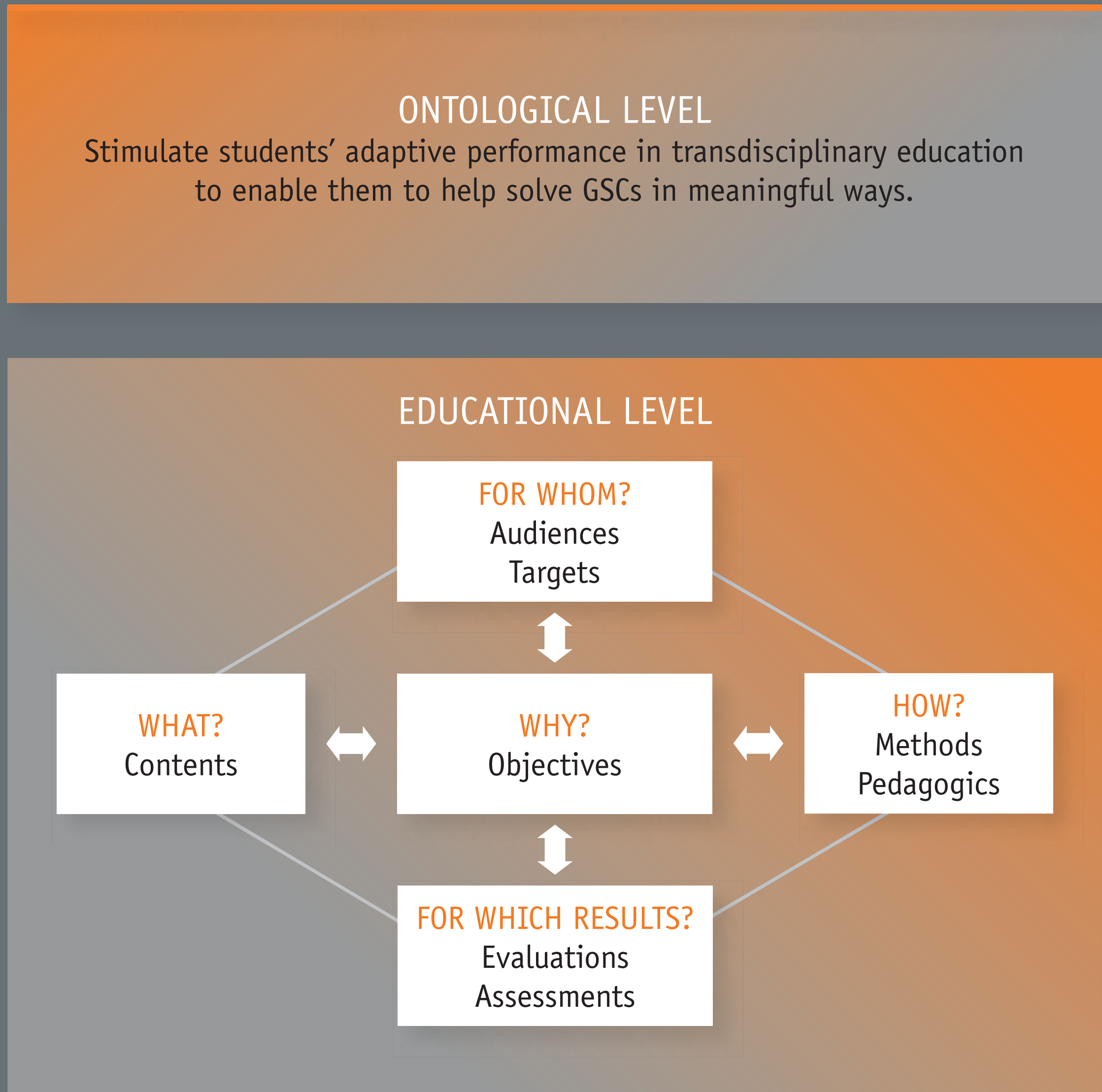
The Peradex consists of design scenarios developed with the help of Artificial Intelligence (AI) and can be used to provide insights into students' performance-based adaptive expertise. The Peradex is available at the edusources website [1]. In the current chapter we share insights on how to use the Peradex in transdisciplinary education, based on a scaffolded approach via which students can gradually develop towards adaptive expertise and start practicing their adaptive performance at the bachelor and master level.

We structure this chapter based on the teaching model framework of Fayolle and Gailly (2008; see Figure 1, p.143). The framework is based on the notion of constructive alignment (Biggs, 1996) and helps to systematically align learning objectives, activities and assessment. Further, the model connects the ontological and educational level. The ontological level captures the underlying aim of education, which is further elaborated in the different dimensions at the educational level. In this chapter, we address each educational-level dimension of the framework. We first conceptualise adaptive expertise and present a model for adaptive expertise development (i.e., *what*), and we translate this to three learning outcomes (i.e., *why*). Next, we discuss how bachelor and master students can gradually develop themselves with regard to the learning outcomes based on a scaffolding structure (i.e., *for whom*). Then, we address how the learning outcomes can be monitored with the Peradex approach (i.e., *for which results*). To conclude, we present design considerations (i.e., *how*) that can be used to create transdisciplinary education as pedagogical approach to stimulate students' adaptive expertise development.

1 Full link: https://edusources.nl/materials/f2663156-3362-4895-a712-a766be7a8c82/adaptive-expertise-assessment

2 In this book chapter, we use disciplines and (knowledge) domains interchangeably.

FIGURE 1 THE TEACHING MODEL FRAMEWORK, ADOPTED FROM FAYOLLE AND GAILLY (2008)



Adaptive expertise and adaptive performance – The What

In this chapter we distinguish adaptive experts from routine experts. Routine experts consistently perform better than others on tasks that are representative for a certain field of expertise. Routine experts have declarative (i.e., knowing-what) and procedural (i.e, knowing-how) knowledge and skills that enable them to solve problems in their domain (Hatano & Inagaki, 1986; Kaffka et al., 2024). They know their domain well and are able to solve problems accurately and quickly (Kaffka et al., 2024).

In contrast with routine experts, adaptive experts are capable of dealing with new problems in their field of expertise in creative and flexible ways (Cheung & Kulasegaram, 2022; Hatano & Inagaki, 1984). Beyond declarative and procedural knowledge and skills, they have conceptual knowledge and skills (i.e., knowing-why). They understand why certain solutions work or not, given a problem situation, and use their conceptual knowledge to "invent" new procedural knowledge (Hatano & Inagaki, 1984, p.30). Adaptive experts also have strong metacognitive skills (Kaffka et al., 2024). Metacognitive skills enable higher level thinking and such 'knowing-why'. Adaptive experts understand principles and relationships underlying a certain domain, which enables them to use their knowledge and skills flexible in novel, non-routine problem situations. They can monitor, regulate, and control their knowledge and skills in such way that they can use their knowledge and skills in new problem situations, and can evaluate thinking processes when working on a task (Akturk & Sahin, 2011).

We define adaptive expertise based on two dimensions: efficiency and innovativeness (Bohle Carbonell et al., 2014). *Efficiency*, also referred to as domain-specific skills, is a basic component of routine expertise. High levels of efficiency help to easily retrieve knowledge to quickly understand and solve a problem (Schwartz, Bransford, & Sears, 2005). *Innovativeness* differentiates adaptive experts from routine experts. Adaptive experts draw analogies to new situations and use their knowledge – decomposed in different building blocks – in new situations. Their metacognitive skills and flexibility helps them to address new problem situations.

The visual expression of adaptive expertise is referred to as adaptive performance (Pelgrim et al., 2022) and is triggered in situations that are characterized by newness – new to the individual or new to the world. We aim to deepen our understanding of how transdisciplinary education can stimulate adaptive expertise development of students and provide opportunities to practice adaptive performance in education.

Near and far transfer

In understanding how students can develop adaptive expertise, transfer is a useful perspective. *Transfer* refers to the extent to which people can use previous learnings in new contexts (e.g., Cheung & Kulasegaram, 2022; Schwartz, Chase & Bransford, 2012). From a cognitive perspective, transfer is perceived as a way to use previously acquired knowledge to new problem situations (i.e., "see the old in the new"; p.1297, Cheung & Kulasegaram, 2022). From a social cognitive and constructivist perspective on transfer, the use of previously acquired knowledge in the process towards the development of new knowledge is more carefully considered, i.e., "see the new in the old" (Cheung & Kulasegaram, 2022, p. 1302). More specifically, in social cognitive theory, transfer is understood as a cognitive process that takes place in a certain social context (Fulton, van der Schaaf, & O'Brien, 2023). Connections and interactions with others – which are key in transdisciplinary education – play an important role in transfer. We define transfer in line with this approach and perceive transfer as a way to explain how adaptive experts are sensitive to "contextual variation" (Schwartz et al., 2012): adaptive experts are capable of understanding what previously acquired knowledge, experiences and skills are useful to address problem situations in new contexts, and at the same time they are capable of understanding how to be flexible, adaptive and creative given the social context and newness of the problem.

Cheung and Kulasegaram (2022) make a distinction between near transfer and far transfer. *Near transfer* relates to problem-solving in similar contexts. *Far transfer* relates to problem-solving in contexts that are further away from the individuals' disciplinary background or knowledge domain [2]. Near and far transfer are personalized, i.e. a task that requires far transfer for a novice (e.g. a student), may require near transfer for an expert. We focus in this chapter on students who perceive tasks differently compared to professionals who can rely on rich working experience. With this notion in mind, we present a model for first steps in adaptive expertise development.

Model for adaptive expertise development

Building on the two main dimensions of adaptive expertise (i.e., efficiency and innovativeness) and near and far transfer, we propose a model for adaptive expertise development (see Figure 2, p.147). We connect near and far transfer to innovativeness. Individuals with adaptive expertise who address new or unusual problem situations in their own domain, demonstrate relatively low levels of innovativeness (i.e., near transfer). Individuals with adaptive expertise have lived experience and a good understanding of that domain, enabling them to solve new problems with relatively low levels of innovativeness. Individuals with adaptive expertise who address problems outside of their own domain, demonstrate relatively high levels of innovativeness (i.e., far transfer). Here, individuals need their adaptive expertise to identify what prior knowledge and experiences may be used to meaningfully contribute to new methods and problem-solving in an unfamiliar domain. Such adaptive experts imagine possible solutions by using prior knowledge in creative and innovative ways. In short, the more distant the new domain is from your own, the more far transfer is required.

In the model, we perceive efficiency – i.e., being a routine expert – as conditional for the development of adaptive expertise. To develop towards an adaptive expert with far transfer, it is advisable to first train routine expertise, and to gradually go from near transfer to far transfer. Starting from declarative and procedural knowledge (i.e., routine expertise), one

2 In this book chapter, we use disciplines and (knowledge) domains interchangeably.

can develop conceptual knowledge which is needed to develop towards adaptive expertise (Hatano & Inagaki, 1986). Yet, following Bransford and colleagues (2005) and Schwartz (2025), we propose that adaptive expertise development requires a combination of practicing efficiency and innovativeness. One can have different levels of efficiency to develop towards adaptive expertise (Schwartz, 2025); overemphasis on efficiency can even hinder the development towards adaptivity. In this regard, Bransford and colleagues (2005) refer to the "optimal adaptability corridor" (p.51), in which the two dimensions (i.e., efficiency and innovativeness) are balanced. Therefore, we do not make a distinction in the model between 'low' or 'high' levels of efficiency. A certain level of efficiency is needed to develop towards adaptive expertise, but there is no golden standard. This also means that a learner can 'move' back and forth between efficiency and innovativeness and should practice both to develop adaptive expertise.

Learning outcomes for adaptive expertise development – The Why

We translated our model for adaptive expertise development to three learning outcomes that can be used to learn and assess adaptive expertise in transdisciplinary education.

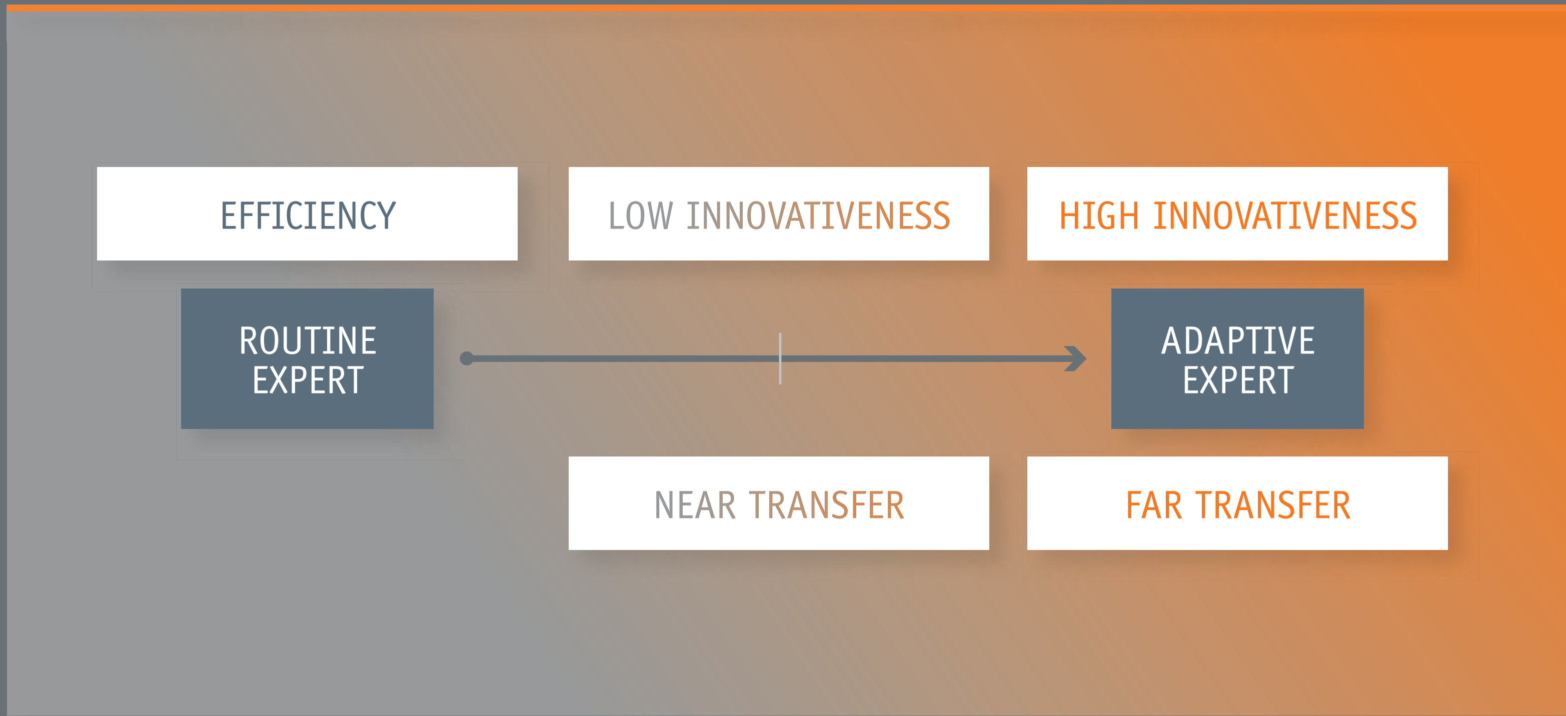
1. **Routine expertise:** The student can apply their knowledge and expertise to contribute to *meaningful* solutions to *familiar* problems in *their own problem domain*.
2. **Adaptive expertise:** near transfer: The student has an understanding of *their own problem* domain in such way that they can apply their knowledge and expertise to contribute to *meaningful* solutions to *unfamiliar* problems in that domain.
3. **Adaptive expertise:** far transfer: The student has an understanding of *problem domains that are not their own* in such way that they can apply their knowledge and expertise to contribute to *meaningful* solutions to *unfamiliar* problems in that/those domain(s).

Each learning outcome can be further specified by replacing 'domain' by a specification of the domain as targeted in a course or other educational intervention. Just as the model for adaptive expertise development, the learning outcomes have a scaffolded structure; each learning outcome builds upon the previous one. Because of the multidisciplinary, social nature of GSCs, far transfer is often needed to come to viable solutions. It takes time to develop adaptive expertise with far transfer. Next, we address how students can gradually develop towards adaptive experts with far transfer throughout their study.

Scaffolding at bachelor and master level – For Whom

Building on the model for adaptive expertise development (Figure 2, p.147), students can be stimulated to develop routine and adaptive expertise in an iterative process in which they practice efficiency and innovativeness. We suggest to carefully design education at the bachelor

FIGURE 2 MODEL FOR ADAPTIVE EXPERTISE DEVELOPMENT



and master level based on a scaffolding approach. Scaffolding is an adaptive form of teaching that suits the support of student learning in complex, uncertain learning environments, such as transdisciplinary education (Bohm et al., 2025). Students with a certain level of efficiency initially practice near transfer, and increase the level of transfer to become further as the students develop themselves over time.

Scaffolding is an interactive process between student and educator. Three main characteristics of scaffolding are contingency, fading and transfer of responsibility (Van de Pol et al., 2010). Educators adjust their support to the level of the student (i.e., contingency). They fade – decrease – the amount of support over time, aligned with the increasing level of the student. Through contingent fading, the responsibility for a task is gradually transferred to the student, which results in an increase of metacognitive skills of the student; in other words, the student takes control over their own learning. Scaffolding can help to support students to become efficient problem-solvers (i.e., routine experts), and next to develop their innovativeness by engaging in learning interventions in which they are challenged to translate their knowledge and skills to new domains and to integrate different perspectives in designing innovative solution pathways for challenges. As such, students practice their innovativeness and develop metacognitive skills, which enables them to develop towards adaptive expertise with far transfer.

This means that developing adaptive expertise with far transfer takes longer than near transfer. We encourage educators to design education in such way that students practice efficiency (i.e., learning outcome 1) throughout their studies at bachelor and master level, at different proficiency levels and in different contexts within their own domain. Students can practice innovativeness within and outside of their own domain gradually over time. In general, during the bachelor study students can practice near transfer (i.e., learning outcome 2) followed by far transfer (i.e., learning outcome 3) at the late bachelor or the master level. This can vary as students, for instance, work on more complex cases within their own domain during the master studies and more simple cases outside of their own domain during their bachelor.

Such variation in task complexity is important for adaptive expertise development (Schwartz, 2025). Whereas efficiency is developed in more stable contexts, innovativeness requires experimentation and risk-taking. By practicing innovativeness in combination with building efficiency, students develop a deep understanding of knowledge and theories, to critically reflect on the relevance of the knowledge they acquired and learn how to translate this to solve new problem situations (Schwartz, 2025). As such, students should practice efficiency in problem-solving and experiment with the development of novel methods and solutions to problem situations that are (partially) outside their own discipline throughout their studies.

Next, we discuss how adaptive expertise can be formatively assessed in education by presenting the Peradex approach, a performance-based assessment for adaptive expertise.

The Peradex approach – For Which Results

The performance-based adaptive expertise (Peradex) is a validated and reliable assessment that measures performance-based adaptive expertise by presenting students with a series of design scenarios that they need to solve (van Rijnsoever, de Jongh, & Baggen, 2026). Peradex is a more objective way to assess adaptive expertise compared to self-assessments[3].

The design scenarios were developed by extending the scenario framework proposed by Walker and colleagues (2006) to measure adaptive expertise as basis, which were developed specifically for engineering design. The Peradex assesses performance-based adaptive expertise along the two main dimensions of adaptive expertise: efficiency and innovativeness. We refer to this as respectively complexity relatedness and cognitive relatedness. *Complexity relatedness* refers to the extent to which the difficulty level of the problem at hand matches the level of expertise of the individual. *Cognitive relatedness* refers to the distance between the individuals' prior knowledge and the problem at hand. Assessing complexity relatedness and cognitive relatedness allows us to explore in what range of novelty individuals are capable to show performance-based adaptive expertise (Bohle Carbonell et al., 2016). GSCs span different domains, and can differ in complexity level. The design scenarios cover different domains and complexity levels, which allows educators to purposively challenge students to practice with efficiency, near transfer and far transfer.

The development of the Peradex scenarios

Using AI (i.e., ChatGPT), we developed 72 design scenarios across three levels of complexity and eight study areas. For each level and area, we developed 3 scenarios (3*8*3=72). Complexity relatedness was operationalized based on the International Standard Classification of Education by the UNESCO (2012). We developed scenarios for three levels of complexity: (1) Upper secondary education (high school), (2) Bachelor's, and (3) Master's. Cognitive relatedness was operationalized based on the study areas as defined by the Dutch Ministry of Education, Culture and Science (2024)[4], which resulted in the areas economics, behaviour and society, healthcare, agriculture and natural environment, nature, law, language and culture, and engineering.

3 The Peradex approach was developed as part of a research project of the EWUU Alliance, a Dutch alliance of four research universities. The alliance universities include engineering education, life sciences, social sciences, and medical sciences. The complete Peradex is available at edusources: https://edusources.nl/materials/f2663156-3362-4895-a712-a766be7a8c82/adaptive-expertise-assessment

4 We merged the categories 'education' and 'behaviour and society', because of their close relatedness. Furthermore, we removed multidisciplinary education as it overlaps with the other study areas.

BOX 1 | EXAMPLE OF DESIGN SCENARIO (AGRICULTURE AND NATURAL ENVIRONMENT; MASTER) | CHARTING NEW PATHS: ECOLOGICAL REVIVAL OF URBAN SPACES

Urbanization has significantly altered the natural landscape, often leading to a reduction in native biodiversity and the disruption of local ecosystems. As cities continue to grow, the challenge of integrating green, biodiverse spaces within urban environments has become increasingly important for ecological balance, human well-being, and sustainability. An urban area, known for its dense infrastructure and limited green spaces, is seeking innovative solutions to reintegrate nature into the cityscape.

The initiative aims to transform underutilized or neglected areas into vibrant ecosystems that support a variety of plant and animal species. This approach involves reimagining urban planning to include green roofs, vertical gardens, urban forests, and waterways that not only enhance biodiversity but also provide recreational areas for the community and contribute to climate resilience.

Problem Statement: Would you use urban planning and design principles to effectively reintegrate biodiversity into cityscapes, transforming urban areas into ecosystems that thrive alongside human activity?

QUESTIONS (try to use 5 minutes per problem case).

1. What is your **proposed solution**? Aim for a solution that is both coherent and practically viable, or describe a process that leads to such a solution (use 100-150 words).
2. How **did you get to this solution**? Discuss which knowledge and experiences (theories, concepts, developments, principles, or practical expertise) you used, and explain the reasoning behind your solution (use 50-100 words).

EXAMPLE ANSWERS

R318: Think in terms of height, there is a lot of space that can still be used up high. Plant long trees or provide beautiful ivy on the houses, it is also a good idea to build a park, which will also be good for the residents. I think people can also be called on to get more small plants, otherwise there is not much that can happen if there is no space. I think there should be more air spaces at apartments where residents can go and where it is not so gray. It might also be a good idea to wrap plants around lampposts, for example, so you use the environment and what you have. Think logically, it is difficult to plant more greenery in a very busy environment. We have the same problem in Utrecht and it is difficult to do something about it, you have to make do with what you have and in this case I think the lampposts are quite a good idea.

R444: would support technologies like sustainability roofs, energy roofs, solar PV panels and overall renewable energy technologies to produce energy in the urban areas. I would also try to build buildings with materials that have low carbon-footprint, are long lasting and doesn't cause harm to environment or biodiversity. Structures and shapes of buildings should also be designed ecologically so we can benefit as much as possible for example from the sun and get efficient water treatment. I would also suggest building green areas and parks wherever it is possible in the urban cities to improve carbon capture and utilization. Overall it is also to support actors that are able to promote sustainable manners.
This is also subject that is very relevant for my studying background. Energy efficiency of buildings, system transition, life cycle assessment calculations are all subjects that are related to the problem. Also my own passion to seek sustainable manners helped me to produce the answer. In my home country Finland, this aspect also a common subject of debate.

Each scenario consisted of a problem description, followed by standardised questions designed to elicit structured responses. The initial set of scenarios was reviewed by a panel of experienced educators, whose feedback guided further refinements of the GPT model, ensuring the consistent generation of high-quality scenarios. In Box 1, we present an example of a scenario from the field of agriculture and natural environment (master) and the standardised questions.

To evaluate the results, we employed an AI-driven pairwise comparison method using the Llama3.1:8B model. In Box 2, we provide an example of instructions for AI, including the selection of the best answer by AI for the design scenario as presented in Box 1. The instructions include rules in relation to the selection of the right answer by AI and are developed in several rounds of adapting the model. The rules are based on careful, human evaluation of the selection of best responses by AI. As AI models develop quickly, we share the instructions in Box 2 as example and inspiration; for each model, new rules must be developed fitting the output of the AI model.

The Peradex is a reliable and valid approach to measuring performance-based adaptive expertise and accounts well for cognitive relatedness, which means that it differentiates effectively between near and far transfer. Complexity relatedness, on the other hand, appeared to have only a small empirical influence on performance-based adaptive expertise (van Rijnsoever et al., 2026).

Using the Peradex in education

Peradex can be used in different ways. At the start of a course or curriculum, the Peradex approach can be used to determine students' base-line performance-based adaptive expertise. Diagnosis can inform a scaffolding approach (Van de Pol et al., 2010), informing the students and the educator about potential, next learning steps.

Next, the Peradex approach can be used to practice adaptive expertise at different moments in time throughout a curriculum. It provides students the opportunity to practice near and far transfer in a controlled environment and can be used as a formative assessment instrument (Black & William, 2009) that informs students on their proficiency to use their prior knowledge and skills in new problem situations, within and outside of their own knowledge domain.

As a course or curriculum progresses, students can work on scenarios at increasing levels of complexity and cognitive relatedness over time to reach the desired level of transfer. Especially given the complex and uncertain nature of learning in transdisciplinary education – which we elaborate on next – the Peradex approach can provide insight into students' performance-based adaptive expertise and provide the opportunity to reflect on their adaptive performance.

BOX 2 | EXAMPLE OF INSTRUCTIONS FOR AI TO EVALUATE THE RESULTS OF PERADEX FOR LLAMA 3.1:7B

INSTRUCTIONS

- You must choose the best response from the two above, identified by respondent-IDs: R318 and R444.
- Nonsensical, incoherent, or irrelevant answers must be immediately disqualified without further analysis. These can never be considered the best.
- Answers that demonstrate a clear lack of effort and understanding of the problem statement can also never be the best.
- Meaningful, detailed answers are better than generic responses.
- Evaluate both responses equally and fairly.
- First, assess the responses in the order presented. Then, reassess them with the order reversed. Compare your argumentations, weigh them equally, and base your final judgment on the most convincing of the two.
- Your final answer MUST ALWAYS begin with the respondent-id of the BEST response to the question, e.g., R072.
- Then write: 'this response is best because...,
- Ensure the respondent-id you select actually appears in the responses.
- Check that your argument for why a response is best aligns logically with the content of the response itself. If not, repeat the evaluation process above.
- Final check: Your final answer MUST ALWAYS begin with the respondent-id of the BEST response. If not, repeat the evaluation process above.

FINAL OUTPUT FORMAT

RXXX this response is best because... [your argument here] The first word of your answer must be the respondent-id of the best answer. The respondent-id always consists of the character 'R' followed by three digits. Then give a brief explanation which answer is best.

SELECTION OF CHATGPT

Response **R444** demonstrates the most adaptive expertise because it shows a deep understanding of the problem and its complexities, as well as the ability to think creatively and flexibly about potential solutions. The respondent's answer is not just a list of ideas, but rather a thoughtful and well-reasoned approach that takes into account multiple factors, such as sustainability, energy efficiency, and environmental impact.

Additionally, R444's response shows an awareness of their own background knowledge and experiences (studying energy efficiency, system transition, and life cycle assessment) and how they can be applied to the problem at hand. This level of self-awareness and ability to integrate knowledge from multiple sources is a hallmark of adaptive expertise.

Design considerations for transdisciplinary education that can stimulate adaptive expertise development – The How

In transdisciplinary education, students contribute to addressing real challenges together with peers and extra-academic stakeholders. Grand Societal Challenges (GSCs), which are complex, uncertain and value-laden in nature (Voegtlin et al., 2022), are prime examples of challenges addressed in transdisciplinary education. These challenges require students to address problems within and outside of their own knowledge domain. They need to engage with extra-academic stakeholders to develop solution pathways. Extra-academic stakeholders can be people with lived experience of the societal issue, sector experts or policymakers (O'Sullivan et al., 2025). Students are challenged to deeply understand the problem at hand, the challenge context, as well as the stakes of different extra-academic stakeholders by emphasizing with them. This is critical for solving GSCs. For instance, in the 2025 Food Systems Innovation Challenge[5] students develop nature-based solutions for local food systems, while addressing climate change and biodiversity restoration, in interdisciplinary student teams together with universities and extra-academic stakeholders from (a.o.) Bangladesh, Ethiopia, Indonesia, Vietnam and the Netherlands.

In this part of the chapter, we distinguish interdisciplinary learning and transdisciplinary learning as two underlying learning processes that are both present in transdisciplinary education and via which adaptive expertise development can be stimulated. Furthermore, it is important to consider the role of the educator in stimulating students' adaptive expertise development. We present design considerations with regard to interdisciplinary learning, transdisciplinary learning and the role of the educator that can be used to design education in such way that it fits their target group and learning outcomes. The design considerations are the final part of our teaching model framework for adaptive expertise development. We present the complete teaching model framework – which is based on constructive alignment (Biggs, 1996) – in Table 1 (p.154/155) and next elaborate the different design considerations.

Design consideration: Interdisciplinary learning

Interdisciplinary learning refers to learning across disciplinary or domain-specific boundaries (Vereijken et al., 2023). In transdisciplinary education, students are confronted with problems outside of their own discipline, which under certain circumstances can contribute to transfer. By addressing challenges outside their own domain, students can develop a deeper understanding of the disciplinary boundaries of their own domain, and to critically reflect on the relevancy of their prior knowledge and skills for new problem situations (Schwartz et al., 2012). Solving problems that are outside of

5 The Food Systems Innovation Challenge is organised by Wageningen University in 2025. For more information, see: https://www.wur.nl/en/education-programmes/current-students/student-challenge/looking-for-a-challenge/2025-food-systems-challenge.htm

THE TEACHING MODEL FRAMEWORK FOR STIMULATING ADAPTIVE PERFORMANCE IN TRANSDISCIPLINARY EDUCATION

ONTOLOGICAL LEVEL Stimulate students' adaptive performance in transdisciplinary education to enable them to help solve GSCs in meaningful ways			
EDUCATIONAL LEVEL			
WHAT: PERFORMANCE-BASED ADAPTIVE EXPERTISE			
	Routine expertise and performance (efficiency)	Adaptive expertise and performance with near transfer (innovativeness)	Adaptive expertise and performance with far transfer (innovativeness)
WHY: LEARNING OUTCOMES			
	Learning outcome 1: The student can apply their knowledge and expertise to contribute to *meaningful* solutions to *familiar* problems in *their own problem domain*.	**Learning outcome 2:** The student has an understanding of *their own problem* domain in such way that they can apply their knowledge and expertise to contribute to *meaningful* solutions to *unfamiliar* problems in that domain.	**Learning outcome 3:** The student has an understanding of *problem domains that are not their own* in such way that they can apply their knowledge and expertise to contribute to *meaningful* solutions to *unfamiliar* problems in that/ those domain(s).
FOR WHOM: STUDENTS IN HIGHER EDUCATION			
	Students are stimulated to develop routine expertise from the start of their bachelor study. They further develop routine expertise in their bachelor and master study at different proficiency levels and different contexts within their domain.	Once students have a certain level of routine expertise, education can be designed in such way that they are stimulated to gradually practice near transfer in their bachelor study. More complex challenges within their own knowledge domain can be practiced at the master level.	Students can be stimulated to gradually practice far transfer at the late bachelor and in their master study, in which they are challenged to translate prior knowledge to new problem situations outside of their own problem domain. More simple challenges outside of their domain can be practiced at the bachelor level.
FOR WHICH RESULTS: THE PERADEX APPROACH			
USE OF THE PERADEX APPROACH	The Peradex approach can be used to determine a baseline performance-based adaptive expertise, informing the educator and the student on next learning steps. The selected design scenario matches the complexity level and study area of the student.	Variety in complexity relatedness, including complexity levels matching and (if possible) higher compared to the students' complexity level. Selection of scenarios in the own, familiar knowledge domain.	Variety of complexity relatedness and cognitive relatedness. The further away the selected domain from the own domain, the more the student is challenged to practice far transfer.

HOW: DESIGN CONSIDERATIONS			
INTERDISCI-PLINARITY	Not required.	Familiar or related domains, for instance going from electrical engineering to civil engineering. A limited amount of domains are required to address the challenge.	Unfamiliar or distant domains, for instance going from mechanical engineering to political sciences. Multiple domains are required to address the challenge.
TRANSDISCIPLINARITY	Not required.	The disciplinary background of the extra-academic stakeholders can be less distant to the background of the students to practice near transfer (e.g., a mechanical engineering student collaborates with a mechanical product engineer). Extra-academic stakeholder for instance in the (less complex) role of commissioner or project manager. Co-creation with a limited number of extra-academic stakeholders.	The disciplinary background of the extra-academic stakeholders can be more distant to the background of the students to practice near transfer (e.g., an electronics engineering student collaborates with an activistic politician to create efficient public transportation). Extra-academic stakeholder can have different roles, such as project manager or content expert. Co-creation with multiple extra-academic stakeholders.
THE ROLE OF THE EDUCATOR	The educator as domain expert who supports students to deepen their knowledge and skills in a certain domain, for instance by sharing detailed instruction, demonstrating task performance, or providing detailed feedback.	The educator as domain expert shares scientific insights, provides feedback and stimulates co-creation with others. The educator as coach monitors the learning process of the students on a regular basis, based on a scaffolded approach.	The educator as domain expert becomes a co-creator of potential solutions. The educator as coach supports students to translate their knowledge and skills to new problem situations by providing hints and cues, based on a scaffolded approach. The educator as coach also asks reflective questions to stimulate self-regulation.

the students' knowledge domain, requires students to enrich their existing knowledge and skills (i.e., efficiency), with new insights from the knowledge domain of the problem at hand (i.e., innovativeness). When the problem discipline is further away from the students' own discipline, far transfer is needed. For instance, applying knowledge and skills from electrical engineering to civil engineering requires near transfer; whereas applying knowledge and skills from electrical engineering to political sciences requires far transfer – as it entails a different understanding of how knowledge is gathered and validated, and how problems are solved.

Design consideration: Transdisciplinary learning

A key feature of transdisciplinary education is learning across different parts of society (McGregor & Volckmann, 2013). Extra-academic stakeholders and peers form an essential, though often hard-to-capture, part of the learning process. Extra-academic stakeholders can, for instance, be challenge agents or sector experts. As challenge agent, extra-academic stakeholders introduce the challenge to the students and can have an advisory role throughout the process and in the assessment. As sector experts - including people with lived experience of the impact of a challenge, such as floods which are caused by climate change – students learn to see the challenge from different perspectives (O'Sullivan et al., 2025). Through the interactions with these extra-academic stakeholders, students are exposed to alternative perspectives, potential misalignments in values, and unpredictability at the problem and solution-side (Visscher et al., 2022). This encourages them to truly empathise with others, which enables them to gain a deep understanding of the problem context, and what it means for different stakeholders involved. Further, they co-create possible avenues for solving the issue with these extra academic stakeholders, from which they learn to develop viable, new and innovative solutions, which fit the context and specific problem situation at hand. As such working with extra-academic stakeholders helps them to develop their innovativeness and learn to become adaptive experts.

Although it is hard to capture near and far transfer in transdisciplinary learning, we expect that in general the disciplinary background, the function and the level of engagement of the extra-academic stakeholders plays a role in this regard. The disciplinary background can be close or more distant from the disciplinary background of the student. Further, it might be more challenging to work together with an extra-academic stakeholder in the role of content expert (distant to the student's disciplinary background), compared to an extra-academic stakeholder in the role of project manager. Lastly, the level of co-creation with extra-academic stakeholders can differ. We expect that the co-creation of solutions together with a wide variety of extra-academic stakeholders across different disciplines and Organisations can stimulate adaptive expertise development with far transfer. Also here, it is important that the educator aligns the level of complexity and uncertainty in the learning process with the target group and learning outcomes, based on a scaffolded approach.

Design consideration: The role of the educator

The role of the educator in transdisciplinary education is complex and not always clear to the student and the educator themselves (O'Sullivan et al., 2025). We distinct three roles educators can have in transdisciplinary education: the educator as domain expert, coach and co-creator of solutions. Based on a scaffolded approach, it is important that the educator matches the teaching strategy to the situation at hand and the response of the students (Van de Pol et al., 2010). Bohm and colleagues (2025) name three techniques to scaffold students towards problem-solving in uncertainty.

First, educators can mark critical features to support students task performance, for instance by checking if students understand given feedback. Second, direction maintenance can help students develop their metacognition, for instance when students and educators discuss the potential effects of certain solution pathways. Third, with frustration control educators can help students to deal with the potentially overwhelming amount of uncertainty students have to deal with in transdisciplinary education, particularly at the start of addressing a societal challenge. Educators can use these scaffolding techniques in their different roles.

To build efficiency, the educator as domain expert can for instance provide detailed instruction, demonstrate a complete procedure or solution, or provide detailed feedback on task performance. To build innovativeness, the role of domain expert becomes less important, as students master their expertise themselves. Rather the educator can provide hints or suggestions to find analogies between the domain knowledge of the student, and the problem at hand, to come to a solution. Here, the educator could also take the role of co-creator of potential solutions, as the expertise of students and educators becomes more alike, and can participate in joint efforts in creating the best solution. As coach, the educator can focus more strongly on the learning process, and how students solve problems outside their domain while working with extra-academic stakeholders. Initially, the educator as coach can monitor the learning process of the student. When the students develop towards far transfer, the educator as coach can have a more facilitating role, ask reflective questions, and encourage students to empathise with others, so that they learn to steer their own learning. Such coaching can accelerate students' understanding of the value of different perspectives to the problem and use such input to develop more meaningful solution pathways. Especially given the uncertain nature of learning – the co-creation of solution pathways with extra-academic stakeholders is unpredictable and full of so-called learning surprises (Baggen et al., 2022) – we expect that the role of the educator as coach compared to the role of the educator as domain expert increases in importance when students develop towards adaptive expertise with far transfer, to help the students to learn the most from such learning surprises.

Pelzer, Hoffman and Hajer (2024) shared their experiences with mixed the classroom in which students and practitioners (i.e., extra-academic stakeholders) learn together and co-create solutions for societal problems. Pelzer and colleagues (2024) refer to their role as 'tinkering'; ongoing reflective processes on learning (i.e., pedagogies) on the one hand and institutional dynamics (i.e., conflicting dynamics of education and practice) on the other. In this article, they reflect on the "good deal of uncertainty" (p. 8) they had to deal with and the importance of failure in creating such education. Further, Bohm and colleagues (2025) found that educators struggle with diagnosing team dynamics and students' personal development in group processes, which may hinder educators to apply different scaffolding strategies. The role of the educator in transdisciplinary education is changing and higher education institutions should carefully consider how to prepare and facilitate their educators best. Not only students are challenged to deal with uncertainty, but also educators. It might help to work together in teams consisting of a variety of educators, for instance with experience outside of academia, having adaptive expertise with far transfer themselves, and novice educators for whom it might be easier to empathise with the students.

Concluding remarks

In this chapter, we developed a model for adaptive expertise development integrated with the issue of transfer in transdisciplinary education. Further, we presented learning outcomes with a scaffolded structure, addressed how students can gradually develop adaptive expertise with far transfer in transdisciplinary education and discussed the Peradex approach which can be used for formative assessment purposes.

We conclude this chapter with a call to researchers and educators to further use, test, and develop the design considerations for adaptive expertise development and create constructively-aligned transdisciplinary education. Also, inspirational practices can help to further illustrate how adaptive expertise development can be translated to educational practice. Specifically, the use of the Peradex approach can be further explored for formative assessment purposes in education. The Peradex approach is accessible online[6]. With the current chapter we aimed to provide concrete suggestions on how to design constructively-aligned transdisciplinary education that enable students to practice adaptive performance as a key capability to help solve GSCs.

6 https://edusources.nl/materials/f2663156-3362-4895-a712-a766be7a8c82/adaptive-expertise-assessment

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