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Teacher strategies that foster students' boundary-crossing expertise when addressing problems with wicked tendencies

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ABSTRACT

Professionals are increasingly involved in attempts to understand and address problems with wicked tendencies, which require crossing boundaries between disciplines, organisations and stakeholder perspectives. This multiple-case study investigated six higher professional education courses in order to develop better understanding of how teachers foster the development of students' boundary-crossing expertise through enhancing relevant learning processes in courses focussing on wicked-problem-solving in interdisciplinary and multi-stakeholder contexts. We viewed students' relevant learning processes as learning mechanisms that foster boundary awareness (identification and reflection) and boundary work (coordination and transformation) and considered teachers to be enablers of such learning processes. Data came from semi-structured interviews with teachers, students and stakeholders, observations and document study. We identified nine interrelated enabling strategies teachers used. To foster students' observation of wickedness through boundary awareness, they encouraged mutual acquaintance, open exploration, opportunities for learning, and multi-perspectivity. To foster students' action through boundary work, they encouraged initial contact, joint action and multifaceted perspectives on value creation. To foster the interplay between boundary awareness and work, they encouraged successive refinement and structure while embracing wickedness. Balancing the tension that students experience at boundaries when navigating complexity, uncertainty and value divergence was identified as an important element of these enabling strategies.

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Introduction

Professionals are increasingly confronted with problems characterised by complexity, uncertainty, and value divergence, considered central features of

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wickedness (Head and Alford 2015; Termeer, Dewulf, and Biesbroek 2019). Addressing problems with these wicked tendencies is challenging, and requires the engagement of different stakeholders, diverse expertise and experiences, mutual learning and coordinated action (Head and Alford 2015). Consequently, higher professional education (HPE) aims to prepare students for understanding and addressing real working-life problems with such wicked tendencies (Neubert et al. 2017). In recent decades, problems with wicked tendencies have come onto the scene in HPE curricula, in settings requiring students' collaboration with various stakeholders and students across disciplinary, organisational and social boundaries. Examples are crossover projects between multiple programmes where students address complex societal issues, innovation projects where students create blueprints for start-ups to generate innovation with new applications of existing technologies (Veltman, van Keulen, and Voogt 2019) and hybrid learning configurations where different stakeholders co-create knowledge and learn in the process (Wals, Lans, and Kupper 2012).

Inclusion of such problems in HPE curricula, however, does not necessarily lead to the intended learning processes. Gulikers and Oonk (2019) found that students showed less collaboration and stakeholder interaction than expected when confronted with problems in multi-stakeholder environments. According to Vartiainen et al. (2022), teachers are often unaware of issues regarding joint regulation experienced by students during collaborative problem-solving processes. Veltman, van Keulen, and Voogt (2019, 2021) found that teachers find it difficult to recognise, understand and balance the tension students experience when dealing with wickedness. This tension, which fosters learning when constructive, but inhibits learning when destructive, indicates discontinuities in (inter) actions among practices and perspectives, referred to as boundaries (Akkerman and Bakker 2011). When confronted with wickedness, students encounter boundaries, such as diverging stakeholder perspectives or different modes of operation among students from different programmes. Wicked-problem-solving requires learning with respect to these boundaries. Despite growing awareness that current pedagogies and forms of learning in HPE fall short in preparing students for dealing with complexity, change and uncertainty (Lotz-Sisitka et al. 2015), very little is yet known about how students' boundary-crossing learning can be fostered in the context of addressing problems with wicked tendencies in HPE. Empirical studies focussing on teacher strategies for fostering students' boundary-crossing learning during wicked-problem-solving in interdisciplinary and multi-stakeholder settings are still scarce (Vartiainen et al. 2022; Wei et al. 2020).

Building on a previous study, which focussed on how wickedness can serve as a catalyst for the development of students' problem-solving skills (Veltman, van Keulen, and Voogt 2021), the current study seeks to contribute to better understanding of how teachers can foster students' boundary-crossing learning when dealing with problems with wicked tendencies. Using the boundary-crossing learning mechanisms (identification, reflection,

coordination and transformation) identified by Akkerman and Bakker (2011) to characterise students' boundary-crossing learning processes, this article examines promising teacher strategies for fostering these learning processes.

Theoretical framework

Problems with wicked tendencies

The term *wicked problems* was first introduced by Rittel and Webber (1973), to describe a category of complex societal problems characterised by ill-definedness, ambiguity, multi-dimensionality, open-endedness and resistance to solutions. At present, many scholars agree that complexity, uncertainty and diverging stakeholder perspectives and values are central features of wickedness (Head and Alford 2015; Termeer, Dewulf, and Biesbroek 2019). We understand wickedness as the combination of complexity, uncertainty and value divergence (Head 2008). In a previous study (Veltman, van Keulen, and Voogt 2021), we examined how wicked tendencies of problems can provide motives for shared activities and meaning-making processes. We distinguished nine characteristic manifestations of wickedness that students encounter and should learn to deal with: the system-like nature, changing patterns and fragmented character of the problem; the transdisciplinary, adaptive and participatory character of the problem-solving process; and the integral, provisional and mutually-shared character of the outcome.

An extensive body of literature has focussed on action strategies for dealing with wicked problems (Head 2008; Koppenjan and Klijn 2004; Roberts 2000). Termeer et al. (2015) emphasised that wicked problems also require alternative ways of observing wickedness. Noordegraaf et al. (2019) stressed the importance of observing the experiences, relations, routines and rituals of people and practices involved in wicked problems. Furthermore, Termeer et al. (2015) pointed to the need for enabling alternative ways of observation and action strategies for problems with wicked tendencies, in terms of cultures and arrangements. In HPE, this refers to teacher support and enabling conditions allowing for students' meaningful modes of observing and addressing wickedness (Veltman, van Keulen, and Voogt 2021). Veltman, van Keulen, and Voogt (2021) found that students experienced different degrees of tension when addressing problems with wicked tendencies in HPE courses, given their dynamic and open-ended nature (uncertainty), the diversity of stakeholder perspectives (value divergence) and complexity. Fostering students' learning (to observe wickedness and to engage in action strategies) requires teachers to balance and leverage constructive tension (Veltman, van Keulen, and Voogt 2019).

Boundary crossing: learning mechanisms and support

We use the concept of boundary crossing (Engeström, Engeström, and Kärkkäinen 1995; Wenger 2000) to characterise students' learning in the context of modes of observing and engaging in action strategies when dealing with problems with wicked tendencies. Boundaries are defined as 'sociocultural differences that lead to discontinuity in action or interaction' (Akkerman and Bakker 2011, 139). The tensions students experience when confronted with wickedness are inherent in the boundaries encountered. These boundaries can be problematic when students do not manage to cross them, but also valuable, given their potential for learning (Wenger 2000), innovation and problem solving (Termeer et al. 2015). Boundary crossing is 'a process of establishing continuity in a situation of sociocultural difference' (Akkerman and Bakker 2011, 152), and refers to efforts and (inter) actions by individuals or groups from different practices at the experienced boundaries, or the participation of a person in multiple practices (Akkerman and Bruining 2016).

Dialogical learning mechanisms of boundary crossing

To identify students' learning processes at/across boundaries, we used the boundary-crossing learning mechanisms (identification, reflection, coordination and transformation) and characteristic processes specified by Akkerman and Bakker (2011). The mechanisms fulfil different functions and have different orientations. Addressing problems with wicked tendencies requires boundary awareness through learning alternative ways of observing, and joint work at boundaries through learning to engage in alternative action strategies (Andersson 2016; Termeer et al. 2015).

Boundary awareness, is about understanding similarities and contradictions and negotiating multiple meanings (Akkerman and Bakker 2011). In the wicked-problem context, it entails understanding the activities and perspectives of the others involved, which inform and provide context for one's own activities and vice versa. Identification and reflection serve as foundations for developing boundary awareness (Andersson 2016). *Identification* refers to learning about practices in relation to one another. It entails encountering and reconstructing boundaries between practices, focusing on renewed sense-making of practices and reconstruction of current identities. Typical identification processes are *othering* (i.e. defining practices in relation to one another, delineating differences) and *legitimising coexistence* of different practices. *Reflection* encompasses the comprehension and explication of one's own practices and those of others, resulting in an expanded set of perspectives and the construction of a new identity that can inform boundary work. Typical reflection processes are *perspective-making* and *perspective-taking*: clarifying a person's understanding and knowledge of a particular issue; and looking at oneself through the eyes of

others. Reflection can lead to mutual meaning-making (Akkerman and Bakker 2011).

Boundary work refers to the practical actions carried out in the shared problem space. The learning mechanisms at play are coordination and transformation (Andersson 2016). *Coordination* is about overcoming boundaries and (re-)establishing continuity by facilitating movement and effective collaboration between practices, as much as necessary to maintain the workflow. Typical processes involve: *communicative connection* between practices, *efforts of translation* between different practices, *enhancing boundary permeability* to make actions run smoothly and procedures that make cross-boundary coordination a *routine*. *Transformation* leads to profound changes in practices or the creation of new (in-between) practices. The transformation process typically starts with *confrontation* with some problem or issue that leads to the reconsideration of current practices by the people involved, followed by the recognition of *shared problem space*. It involves continual *joint work between practices*, the *hybridisation* of perspectives and activities and the *crystallisation* of new ideas, while *maintaining* a certain degree of *uniqueness* of the practices involved (Akkerman and Bakker 2011; Akkerman and Bruining 2016).

Boundary-crossing support

Teachers can support students' boundary crossing in various ways: 1) *brokering* by teachers who participate in different contexts; 2) using *boundary objects* with a bridging function, in the form of physical artefacts, discourses, or shared processes; 3) fostering *boundary interactions* in a more or less structural way and 4) the *organised reflection* on these interactions; 5) optimising *degrees of freedom*, referring to the flexibility to adapt to students' learning in different contexts, such as through the validation of informal learning and flexible modes of delivery; 6) optimising *degrees of clarity*, referring to consistency between expectations and requirements for students and being transparent about expectations and 7) *supervision*, which refers to support in coping with experienced boundaries and related tensions (Arts and Bronkhorst 2020; Bronkhorst and Akkerman 2016; Wenger 2000).

Research questions

This study aims to develop better understanding of how teachers can foster the development of students' boundary-crossing expertise through enhancing learning processes in courses that focus on addressing problems with wicked tendencies. Consequently, the questions this study addressed were:

(1) What strategies do teachers use to foster students' boundary awareness and how do they contribute to students' observation of wickedness?

(2) What strategies do teachers use to foster students' boundary work and how do they contribute to students' action strategies for dealing with wickedness?
(3) What strategies do teachers use to foster the interplay between students' boundary awareness and boundary work?

To answer the research questions, a multiple-case study design was used, with six courses (i.e. modules, classes) in HPE dealing with problems with wicked tendencies as cases, and students and teachers as units of analysis (Yin 2014).

Methodology

Context, cases and participants

The study took place in the context of a curriculum revision at an HPE institute (i.e. University of Applied Sciences) in the Netherlands. As well as in other countries, vocational education in the Netherlands is 'concerned with learning about, for and across working lives for all' (Bruijn, Billett & Onstenk 2017a, 2017b p. ix). In addition to their primarily aim to prepare and qualify directly for work and career, Dutch vocational education programmes also aim to deliver qualifications for citizenship and social participation, and for further learning and personal growth (Bruijn, Billett & Onstenk 2017, 3, 10).

Higher education in the Netherlands has a binary structure, incorporating both academic education (i.e. bachelor- and master level studies provided by academic universities, positioned at ISCED Level 6) and Higher Professional Education (i.e. HBO) offered by Universities of applied sciences. Besides 4-year professional bachelor studies (positioned at ISCED Level 5), HPE also includes 2-year associate degree programmes and professional masters (Bruijn, Billett & Onstenk 2017). Students can enter HPE after completing upper secondary general education (i.e. HAVO) or upper senior secondary vocational education at intermediate level (i.e. MBO, positioned at ISCED Level 4) (Bruijn, Billett & Onstenk 2017).

A considerable component of Dutch HPE curricula consist of workplace learning (Onstenk 2017), varying from internships, to field labs, to co-makerships. Professional bachelor's degree programmes in the Netherlands vary in comprehensiveness, and in the extent to which they prepare for specific jobs or work fields. Usually, within the scope of the programme, from the second year of study students have the opportunity to make individual choices (i.e. choosing a specific organisation for their workplace learning, projects, minors and electives) (Van Houten 2018). For example, second year Social Work students choose one out of three profiles (i.e. youth; wellbeing and society; care), and specialise in a topic of their choice (e.g. children and media, psychiatry, addiction, or family problems). Students who complete the bachelor

Social Work, have acquired a range of skills and are employable in a variety of jobs, such as parenting coach, youth worker, addiction prevention officer, rehabilitation officer, mental health/psychiatric assistant (Windesheim University of Applied Sciences 2022).

The cases in our study were (elective) modules or classes (hereinafter referred to as 'courses') that 1) constituted a substantial part of a fulltime professional bachelor's degree programme, 2) were new or redesigned, 3) involved addressing authentic problems with wicked tendencies and 4) involved multi-stakeholder contexts and/or disciplinary boundaries.

The selection procedure identified three elective interdisciplinary courses (with students from different professional bachelor's degree programmes within and/or across domains) and three monodisciplinary courses (i.e. part of the professional bachelor's degree programmes of Social Work, Applied Gerontology, Global Project & Change Management) for first- to fourth-year students, with a study load of at least nine European Credit points (equivalent to 196 hours) and a duration of one or two semesters, involving 12 to 30 students (per class), with teachers who were willing to participate in the study. Table 1 presents an overview of the selected courses.

Participants were teachers, students and stakeholders. The problem contexts involved different stakeholders (e.g. public/private parties, intermediaries, residents). Students worked in groups of two to six, each group addressing a different problem. In four courses, students selected/identified a problem, while in two courses this was done for them. In some courses, commissioners, whose problems were addressed, had an agreement with the programme (e.g. about attending sessions, providing information, guidance, feedback, deliverables). The learning goals and assignments involved boundary awareness and

Table 1. Selected courses.

Course	Programme(s)	Student level	Duration (semesters)	ECTS
Social Enterprise	Interdisciplinary. Programmes from the business domain (e.g. business administration, finance and control, marketing management, human resource management)	Third/ fourth year	1	13
Sustainable Cities	Interdisciplinary. Mainly programmes from the business domain (e.g. human resource management, business administration) and the technology domain (e.g. civil engineering)	Third/ fourth year	1	9
Urban Health	Interdisciplinary. Programmes from any domain (e.g. (socio-psychiatric) nursing, sport studies, applied gerontology, pedagogy, social work, communication, law, marketing management, and pharmacology)	Third/ fourth year	1	30
District Intervention	Social Work	First year	1	10
Good Life	Applied Gerontology	Second year	2	24
Network Building	Global Project & Change Management	Third/ fourth year	1	20

boundary work. The intended stakeholder participation varied, from providing information to co-creation. Depending on the course set-up, the interaction with stakeholders was initiated by teachers, students, or other stakeholders. Table 2 presents a typology of the six courses.

Data collection

Data came from semi-structured interviews, observations and document study. Based on the theoretical framework, document study and information from the course designers, a topic list was developed for semi-structured interviews with teachers and stakeholders, and semi-structured focus group interviews with students (typically one focus group interview per student group). Teachers were interviewed at the beginning (T0) and the end of the course (T1). Stakeholder and student interviews took place at the end of the course. All course teachers were included, except in District Intervention, where 5 of 21 teachers of parallel courses were included. Student groups were selected based on suggestions from teachers and willingness to participate. Final presentations by student groups for teachers (and stakeholders) were observed. Document study included all available information concerning the course: reference frameworks, student manuals, assessment forms, course materials, assignments, the deliverables, learning journals, reflections by students and feedback from peers or stakeholders. Table 3 presents an overview of the data collection methods.

Data analysis

All interviews and observations were audio-recorded, transcribed verbatim and coded by the first author, along with the documents. The main *a priori* coding categories (Saldaña 2015) drawn from the theoretical framework were: boundaries, the three wickedness dimensions, the four boundary-crossing learning mechanisms and the seven modes of boundary-crossing support. Table 4 presents the descriptions of a selection of the codes used, including some examples from our data to illustrate these codes. The co-authors functioned as critical friends during data analysis and interpretation, and revised the translations made by the first author of the quotes used in this article. The research questions were answered by within-case analyses, followed by cross-case analysis (Yin 2014). The teacher strategies for fostering students' boundary-crossing learning were identified by focussing on teachers' and students' experiences during data analysis.

Within-case analysis consisted of four steps. In step 1, relationships between identification/reflection and observing wickedness (RQ1), and between coordination/transformation and action strategies for dealing with wickedness (RQ2) were identified. This step was drawn from the assumptions in the theoretical framework: addressing problems with wicked tendencies requires boundary

Table 2. Typology of the six cases.

		Problem selection		Stakeholders involved				Goals/assignments			Plenary stakeholder interactions			
Case	Overall problem addressed and specific examples	Student-initiated	Teacher-initiated	Commissioners	Individual persons, residents, clients customers	Representatives of organizations, businesses, other entities	Students from other disciplines	Boundary awareness	Boundary work	Personal learning goals	Stakeholders at course level	Matching sessions	In-between sessions	Final presentations
Social Enterprise	Sustainable, social entrepreneurship: ● Relocating a restaurant area in a care home ● Food waste reduction ● Real price of organic food	x		x	x	x	x	x	x		x			
Sustainable Cities	Smart, inclusive, sustainable cities: ● Smart and innovative E-health hub ● Matching sponsors/co-creators for international horticultural exhibition ● Business-park maintenance yielding social return on investment		x	x	x	x	x	x	x		x	x		

(*Continued*)

Table 2. (Continued).

		Problem selection		Stakeholders involved				Goals/assignments			Plenary stakeholder interactions			
Case	Overall problem addressed and specific examples	Student-initiated	Teacher-initiated	Commissioners	Individual persons, residents, clients customers	Representatives of organizations, businesses, other entities	Students from other disciplines	Boundary awareness	Boundary work	Personal learning goals	Stakeholders at course level	Matching sessions	In-between sessions	Final presentations
Urban Health	Health of young urban populations: • Drug use among young people • Collaboration between social services and food bank • Healthy sports canteens		x	x	x	x	x	x	x	x	x	x	x	x
District Intervention	Social cohesion: • Loiterers • Division between buyers and tenants • Individualisation of society	x			x	x		x	x	x				
Good Life	Ageing population: • Fostering interge-nerational contact • Access to public toilets increasing mobility • Games fostering contact and participation	x		x	x	x		x	x	x	x	x	x	x

(*Continued*)

Table 2. (Continued).

		Problem selection		Stakeholders involved				Goals/assignments			Plenary stakeholder interactions			
Case	Overall problem addressed and specific examples	Student-initiated	Teacher-initiated	Commissioners	Individual persons, residents, clients customers	Representatives of organizations, businesses, other entities	Students from other disciplines	Boundary awareness	Boundary work	Personal learning goals	Stakeholders at course level	Matching sessions	In-between sessions	Final presentations
Network Building	Civil society: • Homogenisation in world cities • Financial stress-related depression amongst students • Natural Disaster Recovery through Community Empowerment	x			x	x		x	x	x				x

Table 3. Data collection.

	Interviews				Observations			Document study[1]					
Case	Teachers (T0)	Teachers (T1)	Students	Stakeholders	Group presentations	Group size	Presence of stakeholders	Reference framework	Student manuals/ assessment forms	Course materials/ assignments	Deliverables	Learning journals/ reflection reports	Feedback from stakeholders/ peers
Social Enterprise	1	3	9		9	4-6			x	x			
Sustainable Cities	2	2	5	2	1	5	x		x	x	x		
Urban Health District	3	4	2	1	6	4-6	x	x	x				
Intervention	5	2	8		8	4-6		x	x	x	x	x	
Good Life	2	2	6	2	5	2-3	x		x	x			
Network Building	3[2]	3			10	2-3	x	x	x	x	x	x	x

Data collection: [1]x = applicable; [2]Took place at T1 in retrospect

Table 4. Coding categories: examples.

Coding category	Code	Description	Example
Dimension of wickedness: Complexity	System-like nature of the problem	Characteristic manifestation of complexity in the problem at stake: complexity of information, interdependencies, and the presence of various subsystems and interrelated subproblems.	'Students often find it hard to see the bigger picture and the context in which it [the problem] is placed . . . and the angles from which it can be seen. You can look at it from a sustainability perspective, a financial perspective, a social perspective. I think they usually kind of get that, but they tend to get stuck at a certain level of abstraction.' (Teacher, Social Enterprise)
Dimension of wickedness: Value divergence	Mutually-shared character of the outcome	Characteristic manifestation of value divergence in the outcome of the problem-solving process: incorporation of a diversity of stakeholder perspectives in the (proposed) solutions, resulting from a participatory approach.	Student 1: 'So, with the idea of building a youth centre, one automatically excludes other groups. That feedback that she gave us was really helpful. Though we didn't really change anything, we learned from it . . .' Student 2: 'Yes, we couldn't do much about it, because we focus on loiterers, but it is something to take into consideration.' (District Intervention)
Learning mechanism: Identification	Othering	Defining practices in relation to one another, delineating differences.	Student 1: 'We wanted to take concrete action right away, and also get clarity about the assignment [from the commissioner]. But we learned that it is important to first . . .' Student 2: 'To read . . .' Student 1: 'To first get to know the exposition as an organisation, with everything around it, to have more knowledge about it . . . Because it helps us to understand and carry out the assignment in a better way.' (Sustainable Cities)
Learning mechanism: Coordination	Routinization	Finding/using procedures by means of which coordination is becoming part of automatised or operational practice.	'It evolves, when you visit them throughout the months. Of course, everyone has developed a different relation with their elderly person. But I think everyone has visited them at home. I was able to build some trust. You have to adapt a bit, because you are a guest in someone's home. The connection felt a bit like friendship.' (Student, Good Life)

(*Continued*)

Table 4. (Continued).

Coding category	Code	Description	Example
Learning mechanism: Transformation	Recognition of shared problem space	Recognition of shared problem space by people involved in the problem-solving process, often in response to a lack or need.	'It was great to have this focus group meeting. We had almost all parties together. Actually, all of them. During the meeting, the discussion between people went like: "Hey, we can do this", and "Hey, this is the problem", and "We agree". So we got more and more support and recognition of the problem and also the solution.' (Student, Urban Health)
Boundary crossing support	Brokering	Brokering by teachers who participate in different contexts	'The ideal teacher in a comaker is the intermediary. On the one hand he empowers students with the right knowledge and skills, and with the right mentality, as support. And on the other hand the teacher should be well-attuned to students, to sense how things are going between students and commissioner. Instead of standing on the side line, so to speak, he should stay in the middle.' (Stakeholder, Sustainable Cities)
Boundary crossing support	Supervision	Support by teachers in coping with experienced boundaries and related tensions.	'At the beginning of the year the teachers said that although learning new things is central to Good Life, we had to be aware of our personal limits. And I do think they have stimulated us to take steps, without going too far.' (Student, Good Life)
Boundary crossing support	Destructive tension (subcode of supervision)	Markers of tension that hinders learning, experienced by students as observed by teachers and/or expressed by students.	'Defining the problem is a learning process in itself. And in this case, the multidisciplinary context and the multitude of stakeholders are an additional complicating factor for students. Like: "We have to deal with multiple parties, and on top, we don't fully understand the needs and assignments." And you see that students tend to get passive, sometimes. Because they don't know what to do.' (Teacher, Sustainable Cities)

awareness through learning alternative ways of observing uncertainty, complexity and fragmentation, and joint work at boundaries through learning to engage in alternative adaptive, participatory and transdisciplinary action strategies. The codes for identification/reflection (RQ1) and coordination/transformation (RQ2), including the sub-codes for their related processes, and the codes for the dimensions of wickedness, including the sub-codes for problem, process and outcome features of each dimension, were explored with matrix coding queries. This provided insight into how students' learning mechanisms at play in boundary awareness (i.e. identification and reflection) contributed to observing wickedness (RQ1) and how students' learning mechanisms at play in boundary work (i.e. coordination and transformation) contributed to action strategies for dealing with wickedness (RQ2). Furthermore, it shed light on when and how the learning mechanisms might typically show up in the context of addressing the problems in the cases and on the mutual interplay between boundary awareness and boundary work (RQ3).

Next, in step 2, any *issues* that students encountered relating to the four learning mechanisms and their sub-processes, including the absence of these learning mechanisms at points where they might be expected (i.e. given the formulated assumptions and given what was revealed in step 1), and including the interplay, were identified.

Step 3 entailed the identification of the *signals* for teachers pointing to these issues. Markers of students' constructive and destructive tension (as observed and reported by teachers and/or expressed by students), as sub-codes for the form of boundary-crossing support *supervision*, were used to identify these signals.

Step 4 involved analysis of how and with what *tactics* teachers anticipated and/or responded (or not) to the issues encountered by students. The codes for the seven ways to support boundary crossing derived from the theoretical framework were used for this step. Relationships between each form of support and each learning mechanism were explored with matrix coding queries to study how the learning mechanisms were encouraged by teachers. As an illustration of the followed procedure, Table 5 presents an overview of the steps taken to identify the teacher strategy Enabling multiperspectivity.

The cross-case analysis consisted of the identification of promising strategies teachers used in relation to these typical issues, enhancing students' boundary awareness, boundary work and their interplay. It entailed the identification of the most typical issues that students encountered related to boundary awareness, boundary work and their interplay and further analysis across cases of the repertoires of tactics of teachers to deal with these typical issues.

Table 5. Illustration of the steps taken to identify the teacher strategy Enabling multiperspectivity.

Step	Procedure	Description of outcome
1. Identification of relationships between learning mechanisms and addressing wickedness	*Assumption*: addressing problems with wicked tendencies requires boundary awareness through learning alternative ways of observing uncertainty, complexity and fragmentation. Exploration of relationship between boundary awareness and observing wickedness by exploring the codes *reflection* (including *perspective making* and *perspective taking*), and the codes for the dimensions of wickedness (including sub-codes for problem, process and outcome features of each dimension) with matrix coding queries.	Insight into how *reflection* contributed to observing wickedness: joint exploration of ways to balance and combine different interests (perspective-making) contributed to the observation of diverging values; observation of uncertainties, such as the impact of possible constraints and assessing the need of possible adaptations; observation of the complexity of the problems at stake, such as the interrelatedness with other issues to be taken into account.
2. Identification of *issues* relating to the four learning mechanisms	Any *issues* that students encountered relating to *reflection* (and the sub-processes *perspective making* and *perspective taking*), including the absence of *reflection* at points where it might be expected given the formulated assumption and what was learned from step 1 were identified.	Identified issue: narrow focus on one party, disregarding or ignoring of other perspectives.
3. Identification of *signals* for teachers pointing to these issues	Any *signals* pointing to the issue identified in step 2 were identified by using *markers of students' constructive and destructive tension* as sub-codes for the form of boundary-crossing support *supervision*.	Markers of students' constructive and destructive tension: Tendency to focus on one party, hesitations to contact other people or representatives from other organisations, procrastination, declining invitations for events/ opportunities to meet a diversity of stakeholders.
4. Identification of *tactics* of teachers to deal with the issues encountered by students	Exploration of relationships between *Reflection* and the seven *ways of support* (i.e. *brokering*, *boundary objects; fostering boundary interaction; organised reflection; optimising degrees of clarity; optimizing degrees of freedom; supervision*) using matrix coding queries.	Brokering: Participation of teachers; Boundary objects: Procedures to foster dialogue (i.e. dialogue tables, emotional touch point technique); Fostering boundary interaction: Introducing new stakeholder perspectives gradually; involving a diversity of stakeholders in organised sessions; Organized reflection: Joint reflection on students' boundary interactions (boundary work) involving a broader group of stakeholders to evoke and clarify identification and reflection processes; Supervision: Optimizing degrees of tension, e.g. by introducing new parties/ perspectives step by step.

Findings

In the following sections we present nine teacher strategies fostering boundary awareness, boundary work and their interplay. For each such strategy we present the typical issue it is related to, the signals pointing to this issue, teachers' tactics regarding the issue, and how the strategy fostered boundary awareness, boundary work or their interplay and contributed to observation or action in the courses.

Enabling the observation of wickedness through fostering boundary awareness

Mutual acquaintance

A typical issue observed in the courses was that students focussed more on understanding the tasks given and getting things done, and less on with whom and getting to know each other in a broad sense. This hindered the identification processes of othering and legitimising coexistence between students, resulting in unused potential. Signals for teachers that students were not attentive to establishing mutual acquaintance were: a strong task-orientation, experienced time pressure and students' motives in choosing group members other than diversity and otherness, such as teaming up with like-minded people.

Teachers used different tactics to facilitate students' mutual acquaintanceship. They organised team formation sessions, let students prepare pitches for potential commissioners during matching sessions and introduced boundary objects to foster students' exploration and mapping of their different qualities, knowledge, perspectives and experiences (Vignette 1).

By enabling mutual acquaintanceship, teachers encouraged development of a clear picture of the available resources, potential, viewpoints and problem-solving capacity (othering) concerning the problems at stake, and laid the foundations for constructive boundary work by encouraging students to consider how they could contribute collectively to the problem-solving process.

Vignette 1 Sustainable Cities: Identification among students using the Team Charter Canvas

The aim of phase 1 of the design-thinking approach in Sustainable Cities was to 'get to know each other, the client and the environment to work in'. To enable this, teachers introduced the Team Charter Canvas: 'With the information and experience gathered the team prepares a team charter canvas in which the team roles, goals, values and expectations are described' (Document study).

'We did this from the beginning . . . it was really nice . . . At first we didn't really understand, but then we took a better look and saw that it's actually about role division, and what you expect from your team. So, then we wrote down how we feel about the team members, how we are as a team member, who's behind the wheel, our expectations' (Student).

Open exploration

Students' focus on tasks and requirements sometimes compromised a thorough, open exploration, and hindered their observation and understanding of the wickedness of the problem. Students then neglected to identify the different people or practices involved in the problem. Signals that open exploration was lacking were a passive attitude, hastiness and students being driven by 'ticking the boxes'.

Teachers' tactics to foster open exploration included: letting students explore local contexts by visiting sites (Vignette 2) and engaging with people before identifying a problem; providing assignments and boundary objects to stimulate the exploration of multiple perspectives, interests and viewpoints (i.e. mapping networks, stakeholders and practices); and providing opportunities to explore a broader group of stakeholders, by ensuring stakeholder engagement prior to the course, or organising encounters with stakeholders.

By enabling open exploration, teachers fostered students' identification of boundaries and common grounds between people and practices (i.e. interests/viewpoints regarding preferred approaches and outcomes) and awareness of possible biases regarding different stakeholder groups. Identification processes contributed to observing value divergence and uncertainty (e.g. changes in stakeholder involvement affecting the problem-solving process). Moreover, students' exploration of different perspectives and available expertise led them experience the benefits of diversity for addressing complexity.

Vignette 2 District Intervention: Exploring the context of future clients

District Intervention students explored social cohesion, inequality and the mutual perceptions of actors at district level.
'It forces students to get immersed in the context of potential clients . . . You can't see someone without their context. You need a clear picture of their social environment, and the problems at district level, and how these can influence someone's well-being' (Teacher).
Students had to describe the ethical dilemmas they experience when visiting the district: 'What preconceptions do I have? Who do I approach, who not? What are my hesitations?' (Teacher). The dilemmas were then discussed in class: 'They experience a lot when walking around in the neighbourhood. 100%. I can see it happen, very nice . . . having an opinion on the matter, you know. . . on the mess on the street, or neighbours complaining about loiterers' (Teacher). Students showed awareness of the need to explore different perspectives: 'You've got to gather information from lots of different people, not just residents, also professionals. Just to obtain a somewhat clear picture' (Student).

Opportunities for learning

Students' concerns with progress, output and results of their assignments often left valuable opportunities for learning unexploited. Signals were a focus on completing assignments and passing the course, often accompanied by experienced time pressure.

Teachers used different tactics to promote an orientation towards learning. They stimulated the formulation of (personal) learning goals and mutual

involvement in each other's learning processes (e.g. by exchanging feedback) and propagated a positive stance towards diversity and the unknown (Vignette 3). They introduced boundary objects (i.e. self assessment reports, reflection reports, learning journals), making students' experiences, struggles and learning aspirations mutually visible. By participating in the problem-solving process, teachers could notice students' blind spots and act as brokers. Teachers organised joint reflections, sometimes also involving stakeholders, to help students experience the learning potential of the diversity of perspectives and expertise. A common pitfall was that organised reflections predominantly took place from hindsight, leaving opportunities to foster boundary awareness and mutual understanding during the course unutilised.

By enabling opportunities for learning, teachers fostered students' mutual understanding and evoked reflection processes, which contributed to observing value divergence and complexity. By exploring different perspectives and viewpoints, students refined their own perspectives (perspective-taking) and encountered suitable combinations of perspectives and expertise (perspective-making) to address the problems at stake.

Vignette 3 Network Building: The destination versus the journey

In Network Building, teachers introduced self-assessment to foster (awareness of) (mutual) learning. Students were guided through the process of self-assessment with forms, instructions and individual meetings with teachers to discuss individual interests, goals and learning objectives: 'We want you to have ownership and awareness about your own learning journey' (Document).

Students' personal learning goals regarded giving and receiving feedback, being open to suggestions from others and developing listening skills: 'I tend to interrupt or give no space when I have a conversation with my teammates' (Student). Students involved peers and stakeholders in their learning journey:

'I will attend a discussion … regarding the [controversial] subject of "Black Piet" … I am sure I will disagree heavily with a certain side. Someone present at the discussion will review my listening skills. Based on that … I will write a short list of lessons learned and learning points for the future' (Student).

Multi-perspectivity

A common issue was that students focussed on and familiarised themselves with the perspective of one particular stakeholder(–group) and their reflection and identification processes only occurred in relation to that stakeholder. This narrow focus compromised a participative, transdisciplinary, adaptive approach. Signals were students' hesitations to contact other people.

Tactics to encourage students to go beyond the safe haven and engage in reflection processes with other parties were introducing new stakeholders gradually, involving different stakeholders in organised reflection sessions or other meetings (Vignette 4) and brokering through active teacher participation. A pitfall was that teachers organised the reflections mainly on boundary interactions between students and with commissioners, much less on interactions with a broader stakeholder group.

By enabling multi-perspectivity, teachers fostered students' joint exploration of ways to balance and combine different interests (perspective-making), which contributed to the observation of diverging values. Students learned about the importance of connecting diverging perspectives and managing uncertainties, such as the impact of possible constraints and the need of possible adaptations. They also learned about the complexity of the problems they addressed, such as the interrelatedness with other issues to be taken into account.

Vignette 4 Good Life: Stretching horizons beyond the safe haven

Good Life students design products and services to improve the quality of life of elderly people. They were highly motivated and committed regarding their relation with the elderly people who participated as buddies:
'In the conversations with the buddy you had to kinda put yourself in his position. You listen to his story. So, you kinda start looking from his perspective. That was valuable, that you have intense conversations and that you learn from the other, how he looks and what his actions are' (Student).
After enriching their perspective with the perspectives of their buddies, students experienced new boundaries when engaging with professionals and encountering new perspectives: 'Professionals have a completely different perspective and say different things' (Teacher). To foster reflection processes with a broader stakeholder group, teachers organised meetings with a diversity of stakeholders: 'It is very nice that school also introduces stakeholders. We had these dialogue tables and the class had a professional that could provide input and contribute to your idea' (Student).

Enabling action strategies for dealing with wickedness through fostering boundary work

Initial contact

A typical issue observed in the courses was students' failure to make initial contact with stakeholders. Signals for teachers were a lack of activities, avoidance, insecurity and hesitation.

Tactics were: lowering the threshold by letting students first explore the problem context and providing chances for multiple attempts to approach people yielding positive experiences; organising stakeholder engagement (e.g. professionals, networks); finding commissioners with already determined problems; organising encounters to enable students to approach stakeholders regarding their specific exploration of problem, reducing insecurities about explaining the purpose of the contact; and formulating establishment of communicative connections with stakeholders as a learning goal, coaching students and eliciting how the problems were explored and information was gathered through the involvement of people. A pitfall was that teachers did not always know what stakeholder interactions were taking place and what students were doing.

By enabling initial contact, teachers paved the way for boundary work, which was essential for a transdisciplinary, participatory and adaptive approach to addressing wickedness. The multiple attempts to contact individual persons (e.g. residents, clients, customers) or representatives of organisations, businesses, or other entities, yielded both positive experiences and doors that

remained closed. This way, students learned about what worked and what did not, and overcame their hesitations (Vignette 5).

Vignette 5 District Intervention: Getting past cold feet

District Intervention students had to analyse a district by making a 'social map', by frequently visiting it and by making a documentary involving different perspectives and groups. Students felt insecure about approaching professionals: 'Because we're so green and unexperienced, I mean, some of us come straight from high school, it can be hard to. . . . approach real professionals, that you look up to maybe'. By helping each other, students learned to cope with tension: 'I find it harder to approach people than the others. And when I see how they do it, I learn from it as well' (Student). Another student added: 'The two of us went out and sat at the bar for a long time, wondering: "What should we ask, to whom and how?" We wrote it down first.'

The students found getting in touch with residents required perseverance: 'That's something we really ran into. I mean, we can be very enthusiastic, but that doesn't mean that our enthusiasm will be shared' (Student). They showed awareness of the need to include different people and groups in their analysis: 'We talked to a school principal and to other people. But do they really have a good image of what's going in in the district?' (Student).

Joint action

Students' boundary interactions ranged from collecting information (coordination) to co-creation and innovation (transformation). However, a common issue was that boundary interactions did not extend much beyond gathering information from stakeholders and dividing tasks among students. Signals were students' fear of making mistakes and fear of rejection by stakeholders (e.g. when receiving feedback, sharing ideas, making contributions).

Tactics to foster joint action were: providing clarity in terms of feasible boundary-work-related learning goals, aligned with roles, learning tasks and assessment criteria, and management of dependencies; the use of boundary objects (i.e. collaboration plans, contracts, order forms); organising sessions with stakeholders, whom students could then involve in their activities; teachers engaged in networks or partnerships fulfiling a broker role, by helping students understand issues at hand, and balancing tension. Shared goals, principles or pillars in these networks and partnerships also served as boundary objects (Vignette 6).

By enabling joint action, teachers fostered processes enhancing boundary permeability and routinisation with commissioners and stakeholders who were involved on a regular basis. The freedom provided enabled dealing with being dependent on stakeholder engagement and collaboration, and fostered an adaptive approach. Coordination with a diversity of stakeholders contributed to participatory action to address value divergence.

Vignette 6 Urban Health: Fostering joint action with network partners

The Urban Health teachers were partners of the local Healthy City Network, which used the national Young People Healthy Weight approach and pillars, such as 'linking prevention and care', which entailed inventory, collaboration and (policy) alignment between the different stakeholders active in prevention (Document study). The course was co-developed with network partners who also participated as commissioners.

Students used 'linking prevention and care' as a boundary object to forge a collaboration between social services and the local food bank. They tried to persuade the poverty coordinator of the need to combine different perspectives: 'She thought poverty problems should be addressed first . . . ' (Student 1). 'Yeah, so first looking at finance, before addressing social issues' (Student 2). 'Eventually we convinced her in a joint conversation that both aspects are important' (Student 1).

Multifaceted perspectives on value creation

Often, students were insecure about the value of their deliverables, in terms of their contribution to the solution of the problem for stakeholders and regarding their grades. Signals were their discomfort with contributing in different ways and a hesitation to make choices and choose direction (e.g. fear that choices that might not yield a promising business case).

Tactics to foster multifaceted perspectives on value creation and enhance students' transformation processes were: providing clarity, by eliciting the purpose of activities and linking them to students' future profession; using approaches, (personal) learning goals and assessment criteria giving room for and acknowledging different activities, roles (i.e. participant versus driver of transformation) and outcomes (Vignette 7); stimulating mutual help; and organising stakeholder engagement and brokering to help students encounter shared problem space.

By enabling multifaceted perspectives on value creation, teachers fostered transformation processes. The process of recognising shared problem space with stakeholders contributed to moving towards an integral and mutually shared outcome. Sometimes, students encountered stakeholders who already had recognised shared problem space, created something hybrid, or even reached crystallisation of new ideas. Learning about stakeholders' roles and boundary work in existing shared problem spaces opened students' eyes to the diversity of possible professional practices they could engage in and contributed to students' professional identity in relation to addressing wickedness.

Vignette 7 Good Life: Making way for provisional and mutually shared outcomes

In Good Life, teachers created a learning environment built on the value of co-creation, with joint meetings with engaged stakeholders and buddies: 'System boundaries fade away, in the sense that professionals are equal to end-users and vice versa' (Teacher). 'All the choices you make in this project are made together with the buddies . . . That's co-creation. You do everything with consent and input from the buddies' (Student).

Students experienced ample room for provisional and mutually shared outcomes of the co-creation process: 'You finalise with an implementation plan, that you hand over to a stakeholder who is interested . . . How far you come differs. That team has a good-to-go plan, whilst in our case there are still things to de done' (Student). Students derived their sense of achievement from the willingness of professionals or other stakeholders to take their plans a step further and from how they were mutually-shared: 'For me it is successful when you see that they are content with what you discuss and what you are developing' (Student).

Enabling the interplay between boundary awareness and boundary work

Successive refinement

A typical issue observed in the courses was that opportunities to let boundary awareness inform work and vice versa were unexploited. Signals were a lack of iterations and experienced time pressure. Approaching deadlines led to pragmatic choices about the division of tasks, and to prioritising getting the job done over an iterative, collaborative approach and grasping opportunities for learning.

Tactics to foster successive refinement were providing flexibility related to time and alternating (organised) boundary interactions and joint reflections, in both larger iterations (e.g. in design thinking) and mini-loops (Vignette 8). In such mini-loops, students' (written) reflections and boundary experiences were discussed in groups. Joint reflection fostered and elicited boundary awareness and informed subsequent boundary work. By enabling successive refinement, teachers optimised learning opportunities regarding observing wickedness through boundary awareness, and action strategies for addressing wickedness through boundary work in interplay.

Vignette 8 Good Life: A disturbed balance, with the final deliverable and deadline in sight

In the first half of the course, Good Life teachers used students' weekly reflection reports to pick up signals and inform their tactics: 'Every week we could see: "do we have to do an intervention, do we have to sit with a team, one-on-one, or do we have to do something with the entire group' (Teacher). However, in hindsight the teachers realised that when professionals and other stakeholders entered the stage, and the collaboration became more complex, this practice, which fostered boundary awareness, became somewhat overshadowed by a focus on deliverables and progress: 'Halfway, the focus shifted towards the product and the business case. In fact, we should have talked more about: "What happens now, what are you learning, what does it imply?"' (Teacher) The other teacher added: 'Focussing on what students encounter at boundaries in co-creation with stakeholders, and reflecting on that … that is much more relevant'.

Structure while embracing wickedness

Another typical issue was students' lack of understanding of how different steps, tasks and assignments were connected and contributed to something bigger, in the dynamic context of dealing with wickedness. Sometimes, students found themselves undertaking tasks without understanding why or to what end, or without knowing whether they complied with the requirements and expected self-direction. Signals were questions, expressions, doubts, behaviour or performances of students indicating that things had gone beyond their understanding.

Teachers' tactics concentrated on balancing tension, freedom and clarity. Tactics involved teachers' proximity and participation in boundary interactions; adaptive teaching (i.e. skipping/introducing activities); ongoing dialogue with students; and clarifying connections and the relevance of perspectives and

elements in the problem context by offering tools and by brokering. A common pitfall was overestimation of students' ability to grasp connections between different tasks and their purpose. In hindsight, some teachers realised they had not provided enough structure for the creation of a deliverable, and that the abstraction was higher than some students could handle.

By enabling structure while embracing wickedness in a process-oriented and adaptive approach, teachers helped students grasp the bigger picture, promoted initiative and fostered interplay between boundary awareness and awareness. Sometimes this was a joint search by teachers and students (Vignette 9).

Vignette 9 Social District: A joint search for balance

The Social District course involved a district analysis and a district intervention, addressing a self-identified social-cohesion-related problem. It was the product of a curriculum revision towards collaboration in learning communities, in which students jointly work on assignments and have self-direction, thus new to both students and teachers: 'It's a big assignment. You need to be able to hold on to something, but that wasn't possible. I think everyone was floundering a bit' (Student). Another student described how the joint search by students and teacher for how to use scheduled hours without falling back on traditional lectures got shaped: 'When we got better contact, it went more smoothly. Halfway we noticed: we have more room, we can take initiative and propose things'. The teacher experienced how the process-oriented approach, with more self-direction and without a pre-defined plan, provided better insight into students' learning processes and needs: 'I see more, and I see it much sooner'. This enabled him to cater for students' learning needs during the process, such as by co-creating a template for their midterm report (deliverable), restoring some clarity.

Conclusion and discussion

By combining wickedness theory and boundary-crossing theory we were able to interpret students' learning when facing the double challenge of understanding wickedness and engaging in joint action for addressing wickedness (Termeer et al. 2015) in terms of the boundary-crossing learning mechanisms of identification, reflection, coordination and transformation (Akkerman and Bakker 2011). This combined theoretical framework allows for an analysis of how teachers in HPE courses enabled students' modes of observing wickedness, through fostering *identification* and *reflection*, the foundations for developing boundary awareness; and enabled students' joint action strategies for dealing with wickedness through fostering students' *coordination* and *transformation*, at play in boundary work (Andersson 2016). By distinguishing between boundary awareness and boundary work and linking these with respectively modes of observing and action strategies, we took a novel approach.

First, we argue that teachers can foster students' boundary awareness by enabling *mutual acquaintance*, *open exploration*, *opportunities for learning* and *multi-perspectivity*. Teachers' enabling role consisted of tackling the typical issues related to identification and reflection processes that hinder students' learning. It is important that teachers are aware of signals pointing to these

issues, such as experienced time pressure and students' focus on products and deliverables. Providing space for discussion and joint reflection can prevent these issues from remaining unnoticed by teachers, and foster students' awareness of how the wicked features of the problems at stake call for adaptive, participatory and transdisciplinary approaches (Veltman, van Keulen, and Voogt 2021; Vartiainen et al. 2022).

Second, we propose enabling *initial contact*, *joint action* and *multifaceted perspectives on value creation* as teacher strategies fostering students' boundary work. Students' insecurity about the value of their deliverables and contributions was associated with the multiple dependencies, uncertainties and unpredictability they had to deal with when addressing authentic problems involving external stakeholders. In participatory, transdisciplinary and adaptive approaches, people bring different qualities to the table, making it important for students to learn about their personal contribution towards a provisional, mutually shared, integral outcome, given their specific (disciplinary) background and qualities. By making room for different contributions and balancing constructive tension in boundary interactions at the limits of students' comfort zones, teachers can foster transformation processes at the intrapersonal level in terms of students' future roles in relation to addressing wickedness and their professional identity in cross-boundary contexts (Bivall, Falk, and Gustavsson 2021).

Third, our study draws attention to how boundary awareness and boundary work are best to contribute to observing wickedness and action strategies when they alternate. We propose enabling *successive refinement* and *structure, while embracing wickedness*, as teacher strategies to foster the mutual interplay between boundary awareness and boundary work. As Andersson highlighted, boundary awareness and work are dialectically related: 'Development of work requires development of awareness, which, in turn, requires work' (Andersson 2016, 258). Preparing students for problems that are unpredictable and not straightforward requires enhancing teachers' reflection-in-action (Schön 1987) in a process- and development-oriented approach. We have argued that the enabling role of teachers is an ongoing balancing act. The inherent unpredictability and the fact that teachers are often not educated in a transdisciplinary manner themselves (Gulikers and Oonk 2019) make this role a very challenging one, as also indicated by the typical issues and pitfalls we have identified. Despite the newness for some teachers of fostering boundary crossing in transdisciplinary, participatory and adaptive approaches, the relevance and advantages were broadly felt. Hannon et al. (2018) also found that teachers experienced teaching students from various disciplines as eye-opening and enriching.

This article addressed the challenging and complex teacher role in HPE courses preparing students for problems with wicked tendencies in a multi-stakeholder and interdisciplinary context. Our study shows that boundary-

crossing competencies can and need to be connected with pedagogical approaches and teacher strategies to prepare students for tackling problems with wicked tendencies, such as socio-environmental problems (Wei et al. 2020). Despite the growing attention to wicked-problem-solving in HPE, few studies have considered teacher strategies for fostering students' boundary-crossing learning in such contexts. The proposed enabling strategies, which link boundary awareness and boundary work with respectively modes of observing wickedness and action strategies for problems with wicked tendencies, may provide guidance for adaptive teacher support to foster students' boundary-crossing learning during the problem-solving process in authentic, unpredictable settings.

Given the focus in our study design on teachers' and students' experiences, opportunities for observing students and teachers in action were limited to the final presentations by student groups for teachers (and stakeholders). To develop further insight into teachers' enabling strategies, further study is needed on teachers' enabling strategies and students' boundary-crossing learning processes in action during the problem-solving process.

Limitations of our study are twofold. First, it included only six cases, and was conducted at a single location. Second, we considered students as a collective. We did observe large differences between students, however. Addressing problems with wicked tendencies provides affordances for students to use and develop different qualities and talents, and to learn about their talents in cross-boundary contexts. Teachers' enabling strategies should cater for the situatedness of the boundaries and tensions experienced by students (Noordegraaf et al. 2019), do justice to their specific needs and ensure better utilisation of differences between students and other problem-solvers, in terms of the skills, knowledge and experiences they bring to the table at 'whatever stage of development' (Guile and Unwin 2020, 4). Future research could therefore focus on how degrees of tension experienced by individual students are related to their dispositions in terms of readiness to deal with uncertainty, ambiguity, multiple frames and a tolerance for open-endedness and risks.

Though these limitations suggest caution in drawing conclusions, our findings may be a first step towards acknowledging the identified enabling teacher strategies. Future research could study how students respond to the proposed enabling strategies and whether students recognise these strategies when addressing problems with wicked tendencies.

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