

Using problems with wicked tendencies as vehicles for learning in higher professional education: towards coherent curriculum design

M. E. Veltman^{a,b,*} , J. van Keulen^b and J. M. Voogt^a

^aUniversity of Amsterdam, Netherlands; ^bWindesheim University of Applied Sciences, Netherlands

This study contributes to a deeper understanding of using problems with wicked tendencies as vehicles for learning in higher professional education (HPE). It was guided by this question: How can the features of problems, problem-solving approaches and outcomes be aligned in HPE courses aiming to prepare students for addressing problems with wicked tendencies? A multiple case study design was used to investigate six courses in HPE. Data came from semi-structured interviews with teachers, students and external stakeholders, observations and document study. Wickedness was defined in terms of complexity, uncertainty and value divergence. Findings showed nine characteristic manifestations of wickedness that students encounter and should learn to deal with. These manifestations pertain to the system-like character, the changing patterns and the fragmented character of problems; the transdisciplinary, adaptive and participatory character of the problem-solving process; and the integral, provisional and mutually shared character of outcomes. The study led to the generation of curriculum design principles for the design and implementation of courses that foster students' skills for addressing problems with wicked tendencies. The conjecture is that students' experiences of wickedness can create destructive tension leading to efforts to reduce this tension by reducing wickedness. Teachers should balance this tension, provide alignment of the dimensions of wickedness in problem, process and outcome and ensure the integration of these dimensions as such in a coherent curriculum design.

Keywords: curriculum development; problem solving; wicked problems; higher education; design principles

Introduction

Complex problems, such as climate change, sustainable development, affordable healthcare and social inequality, require professionals to engage in collaborative, cross-disciplinary and non-linear approaches in multiple-stakeholder contexts (Koppenjan & Klijn, 2004). Higher professional education (HPE) institutions are increasingly taking up the challenge to integrate such challenges in their curricula

*Corresponding author. M. E. Veltman, Department of Education, Windesheim University of Applied Sciences, Windesheim UAS, Campus 2-6, PO Box 10090, 8000 GB Zwolle, Netherlands. Email: m.e.veltman@uva.nl

to prepare future professionals for such contexts (Neubert *et al.*, 2017), drawing on approaches such as design thinking, co-creation, living labs (Veltman *et al.*, 2019) or regional learning environments (Gulikers & Oonk, 2019). In HPE such complex problems are often referred to as wicked problems (Neubert *et al.*, 2017), a term used in a large body of literature since it was first introduced by Rittel and Webber (1973). For three reasons, in this study, we speak of the wicked *tendencies* of problems rather than of wicked *problems* (Newman & Head, 2017): first, complex problems vary in the extent of their wickedness, and wickedness can be understood as a spectrum of difficulties (Alford & Head, 2017); second, an important function of education is to prepare students the world of work (and the for the wickedness they will encounter), referred to by Biesta as the qualification function of education (2009). The purpose of HPE lies in fostering students' *learning*, by providing students with the knowledge, skills, understanding and dispositions that allow them to address wickedness, rather than actually *tackling* wicked problems; third, framing and the scale at which problems are presented to students in the educational setting to be addressed, often leads to a reduction of wickedness.

Because of their complexity, uncertainty and the involvement of stakeholders with diverging views, wicked problems require adaptive, non-routine, collaborative, participatory and cross-disciplinary approaches (Head & Xiang, 2016; Head, 2018). Given the inherent unpredictability of the outcomes of problem-solving efforts to wicked problems, approaches that disregard the dynamic and multidimensional nature of wicked problems are likely to fail (Head, 2018). Despite the growing consensus that more emphasis in HPE curricula is needed on the competencies for adaptive, participatory and cross-disciplinary strategies (Head & Alford, 2015) and on 'enabling learners to develop dispositions and forms of being that will allow them to face the challenges of a future marked by uncertainty' (Anderson & McCune, 2013, p. 155), curriculum designers and teachers often find themselves entering uncharted waters (Gulikers & Oonk, 2019). Successfully preparing students to address problems with wicked tendencies requires a better understanding of the features of these problems, the problem-solving process and its outcome, as well as how they can be aligned in a coherent curriculum design so that tensions are balanced and students' learning is fostered. This study contributes to better understanding of how such problems and the related tasks can serve as vehicles for learning. It aims to generate empirically-grounded curriculum design principles, by studying (re-)designed courses that foster HPE students' skills for addressing problems with wicked tendencies.

Features of problems with wicked tendencies

In response to the increasing complexity of societal problems in the 1960s and 70s, Rittel and Webber introduced the term wicked problems to describe a category of problems requiring a different approach than tame problems (1973). They formulated ten distinguishing properties of wicked problems, which have since been re-framed by different scholars, stressing different elements and perspectives (Termeer *et al.*, 2019). More recently, different scholars have come to understand wickedness as a spectrum of difficulties (Newman & Head, 2017; Turnbull & Hoppe, 2018). Moreover, scholars have proposed new language such as 'addressing' or 'tackling'

rather than ‘solving’ wicked problems (Head, 2018). The focus has shifted to how problems evolve (Head, 2018), how problems are framed and tackled and how stakeholders experience wickedness (Noordegraaf *et al.*, 2019). Wicked problems are ill-structured and dealing with them means, in essence, problem structuring (Simon, 1973; Turnbull & Hoppe, 2018). Because the integration of problems with wicked tendencies in HPE curricula involves some amount of problem processing and problem crafting by teachers, stakeholders, and/or students, it is important to consider the dynamics of problem framing and problem definition.

Many scholars have agreed that complexity, uncertainty and the involvement of stakeholders with diverging perceptions, perspectives and values are central features of wickedness (Head & Alford, 2015; Turnbull & Hoppe, 2018; Termeer *et al.*, 2019). We understand wickedness as the combination of the dimensions of *complexity*, *uncertainty* and *value divergence* (Head, 2008) (see Figure 1). The first dimension, *complexity*, refers to the system-like character of the problem and to the existence of elements, subsystems and interdependencies (Head, 2008). The second dimension is *uncertainty* in relation to risks, consequences of actions and changing patterns with respect to conditions or resources that occur over time (Head, 2008). *Value divergence* and fragmentation in stakeholders’ viewpoints, values and strategic intentions constitute the third dimension of wickedness (Head, 2008). A stakeholder in this context is understood as an individual or group who can affect or is affected by the issue of interest (Glicken, 2000; Freeman, 2010). Stakeholder perceptions, values and interests play a role in ‘how issues are scoped, priorities are set and possible solutions considered’ (Head, 2018, p. 9).

The educational aim in HPE is to use problems with wicked tendencies as vehicles for learning to deal with the dimensions of wickedness, through problem analysis and

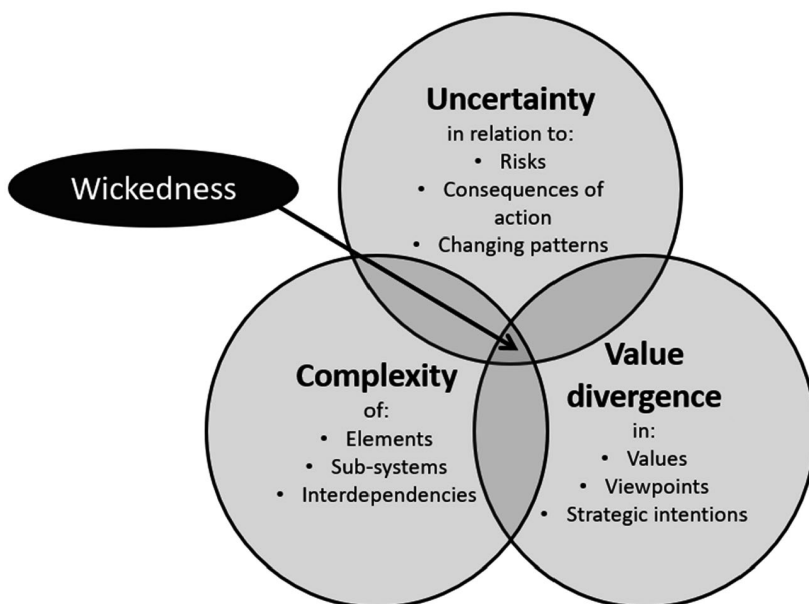


Figure 1. Dimensions of wickedness (after Head, 2008)

problem solving. However, students are not always given the opportunity to experience wickedness through all three dimensions to develop an understanding of the problems. Opportunities for learning are not always realised (Veltman *et al.*, 2019).

Approaches to addressing problems with wicked tendencies

The process of addressing wicked problems is non-linear, complex, chaotic and opportunity-driven (Conklin & Weil). It is a social process, because wicked problems are ‘expressions of diverse and conflicting values and interests’ (Norton, 2012, p. 450). Xiang (2013) argued that the collective and social nature of addressing wicked problems requires a ‘holistic and process-oriented approach that is by nature adaptive, participatory and transdisciplinary’ (p. 2). Participatory approaches foster co-design and innovation through synergies, joint commitment and collective learning (Xiang, 2013; Head, 2018). Since wicked problems cut across (sub)systems and involve a variety of stakeholders, transdisciplinary approaches can be beneficial (Xiang, 2013; Head, 2018).

Actors involved in addressing wickedness face two ‘distinct yet intertwining streams of challenges’ (Head & Xiang, 2016, p. 4), namely *understanding* the problem in all its dimensions and *generating responses* (Head & Xiang, 2016). Regarding the first challenge, Turnbull and Hoppe (2018) argued that problems having wicked tendencies cannot be analysed without considering the relations among the people dealing with them. Regarding the second challenge, Head and Xiang (2016) stressed the importance of enhancing learning and trust among participants by engaging with stakeholders’ goals and interests through an open, process-oriented approach.

Outcomes of problem-solving processes

Solutions to wicked problems are provisional and require continual refinement and adjustment to changing circumstances (Head, 2018). This requires a flexible mindset concerning risk and innovation (Australian Public Service Commission, 2007) and wariness of results-oriented approaches that disregard the difficulties and uncertainties inherent in the problem-solving process (Head, 2018). Progress in addressing wicked problems is related to what stakeholders learn about both the problem and the solution, and is mostly qualitative (Conklin & Weil, 2007).

Moving back to the HPE context, it is important to consider the nature of solutions to problems with wicked tendencies and to coordinate the expectations of students, teachers and stakeholders regarding the intended outcomes. The fact that outcomes are to a large extent provisional, open-ended and qualitative is a challenge for education. Assessment of students’ learning typically considers the solutions generated as the result of the problem-solving-process. Moreover, while wicked-problem-solving is an ongoing process, education is time-bound. Despite these constraints, it is important that students perceive the outcome of the problem-solving process as open-ended and unpredictable (Veltman *et al.*, 2019), so students can ‘learn as they go along about the value and relevance of particular choices and actions’ (Scott *et al.*, 2016, p. 8).

Alignment of problems, problem-solving approaches and outcomes

The dynamics of problem framing and problem definition are closely tied to the type of solution that is proposed (Head, 2018, p. 2). Hence, it is important that problem features, the scale at which problems are defined and addressed, the problem-solving process and its aimed outcome are well aligned in the educational context. Four elements need consideration here. First, from the perspective of situated wickedness, more emphasis is needed on how people *experience* problems (Noordegraaf *et al.*, 2019). Approaches for addressing problems are informed by people's understanding of these problems and by the way people look at them (Rittel & Webber, 1973). Termeer *et al.* (2015, p. 681) warned that 'people tend to ignore those aspects of problems that fall outside the scope of their attention and for which they have no action repertoire'. Mismatches lie in wait, such as between the scale of a problem and the scale at which it is addressed (Termeer *et al.*, 2015) or between 'problems-as-processed-by-official-policymakers' and 'problems-as-experienced-by-social-actors' (Turnbull & Hoppe, 2018, p. 12).

Second, since stakeholders' attitudes towards risk and failure influence the approaches chosen and outcomes, it is indispensable to create a safe *learning culture* that supports experimentation and adaptation (Head & Xiang, 2016), which enables stakeholders to learn to tolerate risks and uncertainties (Head, 2018). Head and Xiang (2016) contend that joined efforts to build and achieve shared goals should be embedded in 'a social learning culture, which allows for rapid adjustments and feedback loops in a participatory environment' (p. 6).

A third element that needs consideration concerns the possible *tension* HPE students experience when confronted with dimensions of wickedness. This tension refers to the 'difference between the current and the desired situation that causes discomfort as the result of a combination of problem characteristics, learning tasks and task conditions, preconditions, and resources' (Veltman *et al.*, p. 153). Veltman *et al.* (2019) found that it is important to balance and leverage the tension students experience when facing 'dilemmas, uncertainties, constraints, and undesired consequences of action' (p. 149). Their study showed that tension was *constructive* when balanced and leveraged according to what students could handle at a certain point, according to their prior experiences (Hennessy & Murphy, 1999), and when constraints were aligned with students' Zone of Proximal Development (ZPD) (Vygotsky, 1978).

Fourth, in addition to the challenges of understanding the problem and generating responses, Termeer *et al.* (2015) mentioned another challenge: *enabling* alternative action strategies and ways of observing to manage the tensions between problem-solvers' ambitions and the (in)formal rules and values of the systems they are dealing with. This can be understood in terms of how the educational system enables meaningful modes of observing and addressing wickedness, and ensures alignment between the learning aims, the activities of students and teachers, and the assessment of learning outcomes.

Research questions

To address the identified gaps in the literature, we propose the following research question for this study: How can the features of problems, problem-solving approaches and outcomes be aligned in HPE courses aiming to prepare students for addressing problems with wicked tendencies? The sub-questions are: (1) What are features of the problems? (2) What are the characteristics of the problem-solving processes (3) What are the characteristics of the outcome of the problem-solving processes? and (4) What (mis-) alignments can be observed between the problems, processes and outcomes?

Methodology

To answer the research questions, a multiple case study design was used, with six courses in HPE as cases, and students, teachers/designers and external stakeholders as units of analysis (Yin, 2014).

Context, cases and participants

The study took place in the context of a curriculum renewal at a university of applied sciences in the Netherlands, stressing the importance of complex authentic problems for educational practice. The cases in our study were HPE courses aiming at fostering students' skills for addressing problems with wicked tendencies, which had been redesigned or newly designed by curriculum design teams (Voogt *et al.*, 2016). The selection criteria for inclusion were: the course (1) is either new or redesigned, (2) has a clear focus on addressing authentic problems with wicked tendencies, (3) involves multi-stakeholder contexts and/or is at disciplinary boundaries and (4) constitutes a substantial part of a bachelor's degree programme. The selection procedure resulted in selection of six (inter)disciplinary courses with a study load of at least nine European Credit points (equivalent to 196 hours), from 1st to 4th year courses, with a duration ranging from 10 to 40 weeks, involving 12 to 30 students, of which teachers were willing to participate in the study. Table 1 presents an overview of the selected courses, including a brief description of the problems at stake.

Participants were defined by their (multiple) role(s) in the courses: designer, teacher, student and external stakeholder. All available teachers (which were sometimes also member of the design team) involved in the course were included for the interviews. However, in District Intervention 5 out of 21 teachers (assigned to parallel courses), were included, considering that this would provide a sufficiently broad range of perspectives. Typically, students within each course worked in small groups on different problems. To further select students and stakeholders within each case for interviews, the problems that appeared most relevant were identified, based on input from teachers. The stakeholders involved in those problems were invited for an interview and the student groups working on these problems were invited for the focus group interviews. In all except one case, student groups were willing to participate in a focus group interview.

Table 1. Overview of the selected courses

Course title	Domain	Programme(s)	ECTS	Study year	Duration (weeks)	Description of problems central in the course
Good Life	Health & Wellbeing	Applied Gerontology	24	2	40	Students co-create with stakeholders and elderly people to develop sustainable product/service innovations for issues regarding the ageing population
District Intervention	Health & Wellbeing	Social Work	10	1	20	After a district analysis, students design a district intervention addressing issues such as social cohesion and loiterers
Urban Health	Health & Wellbeing	Interdisciplinary	30	3–4	20	Students work on research assignments from partners of Healthy City Network. Examples: collaboration between food-bank and social services; healthy sports canteens
Network Building	Business	International Project & Change Management	20	3–4	20	Students search for and connect to networks to address problems related to civil society (global health, urban dynamics and social entrepreneurship)
Social Enterprise	Business	Interdisciplinary	13	3–4	20	Students acquire contracts/assignments regarding social entrepreneurship and develop business cases. Examples: food waste reduction; real price of organic food
Sustainable Cities	Business	Interdisciplinary	9	3–4	20	Students address issues related to smart inclusive cities. Examples: smart health hub; matching sponsors/co-creators for large green event

Data collection

Data collection took place between October 2017 and July 2018. Data about the curriculum *design* were derived from document study of all available information concerning the course: reference frameworks, student manuals, assessment forms, course materials and assignments. Data about the *implementation* of the curriculum in practice were derived from the triangulated methods of semi-structured interviews, observations and document study of the deliverables/documents/materials produced by students. Based on the three dimensions of wickedness, the study of the documents and information from the designers of the courses, a topic list was developed for semi-structured interviews with teachers/designers, stakeholders and semi-structured focus group interviews with the student groups. Teachers/designers were interviewed at the beginning and at the end of the course. Interviews with stakeholders and students took place at the end of the course. Observations concerned the final presentations for teachers (and stakeholders) of all student groups. Table 2 presents an overview of the data collection for the six cases.

Data analysis

All interviews and observations, were recorded, transcribed verbatim and coded by the first author, while the co-authors functioned as critical friends. The main coding categories were: the manifestations of the three dimensions of wickedness with respect to problem, process and outcome; problem framing; problem scale; relation with main stakeholders; and alignment (Saldaña, 2015). Within-case analyses were followed by a cross-case analysis (Yin, 2014). All quotes used in this article were translated into English by the first author and revised by the co-authors.

Findings

The problems in the six courses had wicked tendencies and the student tasks encompassed addressing and understanding these problems. Our findings show that wickedness, broken down along three dimensions, was manifested in features that created *tension* when experienced by HPE students. *Destructive tension* led to undesired coping behaviour of students: attempts to reduce the tension, resulting in reductions of the experienced wickedness and in misalignments between problem, process and outcome. Table 3 presents how wickedness was manifested in the problems, processes and outcomes of the cases in this study. However, given the encountered misalignments, influenced by design characteristics, and the interplay of students' attempts to reduce tension and teachers' efforts to balance and restore constructive tension, the manifestations of wickedness in process and outcome were not observed everywhere. In the following paragraphs, we present our findings regarding the manifestations of the dimensions of wickedness in the problems, the problem-solving processes and the outcomes, as well as their alignment in the courses.

Complexity

The dimension of complexity is manifested in the *system-like character* of the problem, in the *transdisciplinary* character of the problem-solving process and in the *integral*

Table 2. Data collection

Case	Interviews					Observations	
	Document study	Teachers (of which designers) (T0)	Teachers (of which designers) (T1)	Students	Stakeholders	Group presentations	
Good Life	x	2 (2)	2 (2)	5	2	5	5
District Intervention	x	5 (2)	2 (1)	8	0	8	8
Urban Health	x	3 (3)	4 (3)	2	1	6	6
Network Building	x	3 (3)	3 (3)	0	0	10	10
Social Enterprise	x	1 (1)	3 (1)	9	0	9	9
Sustainable Cities	x	2 (1)	2 (1)	5	2	1	1

Table 3. Manifestations of wickedness in problems, processes and outcomes

Dimensions of wickedness	Problems	Processes	Outcomes
Complexity	System	Transdisciplinary	Integral
Uncertainty	Change	Adaptive	Provisional
Value divergence	Fragmentation	Participatory	Mutual

character of the outcome of the problem-solving process. An example illustrates this. A problem addressed by Social Enterprise students, a cleaning company seeking to open a new location employing the long-term unemployed, encompassed various *subsystems* as it required balancing commercial goals and the social goal of inclusion. Students had to combine contributions from *multiple disciplines* and backgrounds to combine social, business and commercial perspectives into an *integral* plan for social entrepreneurship.

Problems. The problems addressed in the courses, such as an ageing population, sustainability, social entrepreneurship and urban dynamics, encompassed various *subsystems* and interrelated subproblems. The problems were characterised by complexity of information (elements) and interdependencies because of the involvement of multiple professional fields, such as care providers, businesses, charity organisations, policy officers and urban planners. The scale at which problems were defined and addressed differed. Teachers experienced an area of tension between two poles. On the one hand, it was their intention to challenge students and expose them to the complexity of ill-defined problems (Sustainable Cities). On the other hand, they tried to make the problems tangible and smaller for students (Social Enterprise). We found that when students adopted a micro-level orientation and had real-life contact with stakeholders, they experienced the system-like character of the problem and gained insight into how other individuals/groups experience the problem (Vignette 1). However, when students studied a problem at a meso-/macro-level, they tended to experience the problem as more abstract and vaguer, and were less likely to delve deep and experience the relations between subsystems.

Vignette 1 District Intervention: ringing doorbells

After a district analysis of written documents and the creation of a social map, students were tasked with visiting the district and engaging with different stakeholders to identify problems that they could design a district intervention plan for. ‘This forces students to explore the context of potential clients. Students tend to have a micro-level orientation, it is always about ‘someone’. It’s great when first-year students realise the importance of a clear picture of how people’s social environment and the problems they experience at the district level can impact their social wellbeing.’ (Teacher).

A student reflected: ‘This course was very exciting, because after reading some stuff online we actually went to that neighbourhood. We got there and kind of tried to ignore our prejudices. I think we managed fairly well. We talked to the district police officer and a social worker and identified a street to focus on, and then we rang some doorbells.’

Process. Our findings show the importance of eliciting how different problem features and the various stakeholder perspectives can be incorporated into a *transdisciplinary* approach. When students began from a micro-level, stakeholder interaction was more intensive than when students began from a meso-/macro-level, resulting in clearer perceptions of the different (disciplinary) backgrounds of the stakeholders involved. Changes in scale/focus induced by learning activities and tasks that shed light on different perspectives or new stakeholder groups during the process increased complexity and the transdisciplinary character of the process. However, not all teachers were aware of the effect this had on the tension experienced by the students.

The process in the courses started with the exploration of a given problem or the task of identifying problems and/or finding relevant stakeholders. Guest-lectures, meetings and experiences with important stakeholders (Good Life, Sustainable Cities) or Challenge Days, in which students worked on complex issues brought in by companies and potential clients (Social Enterprise) facilitated this exploration stage. Students' transdisciplinary awareness and knowledge of system complexity was also explicitly fostered in workshops (Network Building, Sustainable Cities). Students were encouraged to involve professionals with different backgrounds to develop potential solutions. Teachers subscribed to the importance of the use of the different knowledge, experiences and backgrounds of the students and stakeholders involved (transdisciplinary approach) (Vignette 2). However, this yielded mixed results. A problem scale beyond the level of one client/company/organisation was often too new and challenging for students and caused destructive tension. As a result, in some courses, students reduced the complexity by narrowing their focus or by not involving all stakeholders.

Vignette 2 Good Life: co-creation makes system boundaries fade away

Second-year applied gerontology students explored the meaning of a 'good life' for the elderly people they formed a team with. They translated the individual experiences of elderly people into collective themes, such as mobility; created personas and future scenarios; involved professionals with different disciplinary backgrounds in the district; and aligned the future scenarios with local council policies and emerging trends. A teacher elaborated on the transdisciplinary process of co-creation: 'When you talk to health professionals and welfare organisations you often hear: "that's our responsibility" or "our area of expertise" (...) But when you co-create that responsibility is truly shared and system boundaries fade away in the sense that professionals are equal to the end users.' The main stakeholder, the district manager, explained about his role: 'We dance through the scales, from strategic level to the level of the concrete slabs. (...) We make projects land in the neighbourhood.' This created an interesting dynamic with the students who started at the grassroots level and made an opposite movement.

Outcome. Our findings show the importance of eliciting how a thorough analysis of the system-like character of the problem and a transdisciplinary problem-solving approach contribute to the integral character of the outcome (Vignette 3). Reduced complexity through ignoring certain stakeholders, subproblems or through a monodisciplinary focus, leads to products/solutions that neglect certain perspectives or features and are not viable.

In some courses (Good Life, District Intervention, Social Enterprise), students had to develop a business case, elaborate how the proposed innovations could be financed and formulate financial and social value propositions for the different stakeholders and beneficiaries. Moreover, specific standards for the outcome of the problem-solving process were used to encourage students to address complexity and make use of different models or perspectives. In some courses, students had to relate the problems to specific core themes or concepts presented in lectures or workshops, such as health inequities across socio-economic classes and public-private partnerships (Urban Health), and show awareness of the different subsystems.

Vignette 3 Good Life: joint reflection in a living lab

In living lab meetings with students, teachers, stakeholders and the elderly people at different stages in the process students presented their proposed innovations. A student group presented their innovation introducing technology-supported games to reduce the loneliness of elderly people, using tablets and an interactive whiteboard, and supported by trained employees. The stakeholder responded: ‘Very nice, how you plan to use games to foster encounters, but when I heard “support by trained professionals”, that requires a lot from us, we have to make sure that someone is always present. How should that be financed?’ The feedback shared by stakeholders, teachers and their buddies enabled students to look at how complex problem features, such as affordability, manageability and practical feasibility, could be integrated into existing structures.

Uncertainty

The problem features related to uncertainty are mainly reflected in *changing patterns*. Uncertainty also comes to the fore in the *adaptive* character of the problem-solving process and in the *provisional* and open-ended character of the outcome of the problem-solving process. We illustrate this with an example. The students in Good Life explored the meaning of a ‘good life’ for the elderly people they co-created with, aiming to contribute to an age-friendly neighbourhood. It was unpredictable which themes would emerge, with which meanings attached, which stakeholders/professionals had to be involved, and how the co-creation and collaboration would evolve. *Changing patterns* in the neighbourhood and in terms of stakeholders’ engagement required the students to use an *adaptive approach*. The goal was to have their ideas for product- or service innovations adopted by the professionals and people in the local community, giving the outcome of the process of co-creation a *provisional* character.

Problems. Although uncertainty is sometimes not manifested until later during the problem-solving process, it is important to stimulate students’ awareness and tolerance of its different manifestations and encourage learning activities that foster the observation of *changing patterns*. We found that the use of iterative and open-ended approaches and the teachers’ role and positive mindset towards uncertainty fostered students’ awareness of changing patterns.

In some courses (Network Building, Sustainable Cities), students’ awareness and understanding of the different manifestations of uncertainty was fostered in

workshops. In the change management course (Network Building), changing patterns and uncertainty were inherent part of the students' problem definitions. Through the tools and problem-solving approaches that were used, teachers intended to encourage students' awareness of and responsiveness to changing patterns and undesired consequences of actions, in an iterative, adaptive process (Network Building, Sustainable Cities and Good Life). This yielded mixed results, also within courses, due to tension experienced by students. However, despite the non-linear and iterative approaches that were part of the curriculum design, some teachers were rather product-oriented and framed problems as static, intending to make them manageable and concrete for the students (Social Enterprise, Sustainable Cities). This reduced opportunities to experience how a problem may change, and hence reduced learning to cope with uncertainty.

Process. Our findings show that although the experience of changing patterns called for an adaptive and participatory approach, interaction with stakeholders about possible solutions became a source of tension for many students. A lack of stakeholder contact during the process, due to destructive tension, can lead to missing important changes and dynamics and compromises an adaptive approach.

Generally, students felt comfortable approaching relevant stakeholders to explore the problem context. However, the transition to the stage of making plans and generating responses increased tension and marked a boundary, after which stakeholder interaction often became less frequent (Vignette 4). In Good Life, after a semester of discovering and dreaming, students had to develop a business model, which involved making choices and consolidating their solution. A teacher commented on the tension students experienced: 'It was like: "Bang!". Some of them really didn't like that.' A teacher of Social Enterprise described the friction between a problem demanding an adaptive approach, and students' preference for linearity: 'They see it as a hurdle race: formulate the question, theory, interviews, the answer, and off to the finish. But ideally it's ping pong (...) It is my role to show that going back is sometimes the quickest road'.

Vignette 4 Sustainable Cities: missing dynamics from inside the tunnel

Student teams experienced destructive tension, which resulted in undesired coping strategies, such as risk aversion and avoiding feedback from stakeholders. One of the teachers described: 'They've always applied the waterfall principle (...). But in design thinking we say: "implement right away, go to your client, follow steps, but with something you already have"'. The main stakeholder explained: 'I noticed a fairly great fear of sharing plans or mid-term reports, while I think it could really help to share these on both sides [school and client]'. After their final presentation, he had a conversation with the students: 'I watched you go into a tunnel. You came here to get the assignment, then you knew the assignment, and I could check in on you sometimes, "How is it?" and I heard: "No worries, we are doing fine." Now I know you were doing fine, but we could have achieved much more. (...) In the dynamics of our organisation, the world can look very different from one day to the next.'

Outcome. Emphasising the *provisional* character of the outcome of the problem-solving process and setting broad goals that allow for adaptive approaches helps students realise that uncertainty requires such an adaptive approach and yields solutions that are provisional (Vignette 5).

In most courses, the intended outcome was framed as provisional and open-ended. In Good Life, students had to find professionals willing to ‘adopt’ their innovation and to take further steps towards its implementation. A Sustainable Cities teacher highlighted the benefits of working with stakeholders with a long-term orientation, willing to take subsequent steps with a new student team. In Network Building, a broad definition of ‘product’ was used, emphasising the value created, regardless of its form.

Vignette 5 Urban Health: a different twist on the spot

Students tested a method for increasing the participation of pupils in the choice of the physical lay-out of their school environment giving them a voice using pictures. ‘The commissioner wanted to know about the do’s and the don’ts for implementing this method in high schools’ (Teacher). ‘We instantly noticed that the pupils had not brought any pictures. So, we had to improvise, and had them make drawings and maps instead. “What is your ideal picture for the little open field next to school, what would you like?” (student). They improved the method, letting the pupils share their ideas on a market. Teacher: ‘What they did wasn’t innovative, but they really had to adapt and consider: “We had a plan and it doesn’t work, so we have to come up with something new on the spot.” It says something about their flexibility that they were able to give a twist to their original plan.’

Value divergence

Value divergence is manifested in the *fragmentation* in viewpoints, values and strategic intentions of the stakeholders involved, in the *participatory* character of the problem-solving process, and in the extent to which relevant stakeholders *mutually share* the outcome of the problem-solving process. An example illustrates this. A student team of Network Building developed a model to create value in the field of place identity in urban communities. The model was designed to explore the *fragmentation* in perceptions and expectations of inhabitants, businesses of the place, workers, tourists and commuters regarding both the current and preferred place identity. The team adopted a *participatory* approach through collective thinking by integrating the social aspects, based on their belief that ‘people are the users of a place and are therefore crucial’ (students, Network Building). The model helps to yield *mutually shared* outcomes: ‘the individual will feel heard and thus valued, as a sense of inclusiveness is created throughout the process of development’ (students, Network Building).

Problems. Our findings show that the involvement of a variety of stakeholders in the problems at stake and the interdisciplinary group compositions of the student teams/groups contributes to the experience of *fragmentation* in viewpoints, interests and perspectives.

In three courses (Social Enterprise, Sustainable Cities, Urban Health), student teams were interdisciplinary. Furthermore, the problems all involved multiple stakeholders. This enabled students to experience fragmentation. In Good Life, teams with students and elderly inhabitants from an urban district focused on how a good life could be achieved for all generations. Starting from the personal experiences of these elderly people, they identified issues, involving the perspectives (values, viewpoints, strategic intentions) of district professionals and city council representatives.

Whether students actually experienced value divergence depended on the extent to which they involved and interacted with a diversity of stakeholders with fragmented perspectives and on the scale at which problems were defined and studied, and how they were framed (Vignette 6). In an attempt to increase the value divergence experienced by students, teachers organised encounters with stakeholders (Good Life, Urban Health, Network Building) or set explicit criteria to guarantee the involvement of different stakeholders, for instance, in terms of the number of stakeholder interviews (Social Enterprise). Despite these efforts, the positive value of different, although fragmented, viewpoints, interests and backgrounds was missed by some of the student groups. A Sustainable Cities teacher observed that the combination of an ill-defined problem, interdisciplinarity and involvement of multiple stakeholders was a 'bridge too far for some students', and that they became passive, suggesting a destructive tension.

Vignette 6 District Intervention: what will the neighbours think?

Students explored the social cohesion in a social district. After meetings with the district police officer and a social worker they talked to local residents, and experienced the importance of doing field research at street level: 'The local newspaper is known for telling beautiful stories. But if you really talk to people and do research, you find out that there is always something to it' (student). In their presentation the students quoted different local residents: 'It's not like it used to be, when people sat in their front yard, and you could drop by unannounced.'; 'I think it's not that bad. I don't want attention [the planned intervention]. I would like less police here, they interfere with our business.'; 'I lie awake at night, until my son gets home. I don't trust it here. There are many loiterers on that field over there, I'm afraid my son will join them.' The students were overwhelmed by the responses of the stakeholders, as they realised that not everyone would welcome their intervention, or would feel comfortable to participate. As one resident said: 'I don't know what my neighbours will think'.

Process. We found that framing the relation with the main stakeholder as a partnership (addressing a problem *with* someone) and stimulating face-to-face interaction with stakeholders enables students to deal with value divergence through developing a *participatory* approach (Vignette 7). Active engagement of the main stakeholders contributes to a more process- and learning-oriented approach and helps reduce tension. The generation of gradual changes in scale/focus, lead to an increase in experienced value divergence and help balance constructive tension.

The problems in the courses all supposed some kind of relation and collaboration with external stakeholders, referred to as partner, client, commissioner, problem-owner, buddy or professional. The intended relation with the main stakeholder

varied from working *for* someone to working *with* someone to address the problem. In all courses, there were student groups that actively involved multiple parties, such as in District Intervention, where a group arranged meetings with the mayor and city councillors. But there were also groups that sought little stakeholder interaction, such as in Social Enterprise, where one group limited the interviews to a single group interview and mainly used written sources. It required initiative and assertiveness from students to approach stakeholders. Tension and previous experiences played a role. Changes in scale or focus during the process and introducing new stakeholder groups one at the time, increased value divergence gradually, balancing the tension students experienced. In Good Life students experienced increased value divergence when they shifted their focus from the micro-level (elderly people) to a broader group of professionals. ‘David and Emily live somewhere, as do many other people. And there are also all kinds of professionals. The municipality has an opinion on the matter, the province does, too, and there are government policies’ (teacher). The involvement of the broader context surrounding the elderly people caused tension, which was balanced by the teachers through coaching.

Vignette 7 Urban Health: joining forces against poverty, reaching common ground

‘The foodbank is operated by passionate volunteers who take great pride in what they do. We are an aid organisation and want people to live as autonomously as possible and make help from the foodbank redundant. Those two visions clash, and we don’t know how to fix it. We asked the students to explore feasible the options, doing justice to all parties, including the inhabitants’ (main stakeholder). The student team organised a meeting with the parties involved: the foodbank volunteers, social service, the policy officer from the municipality and succeeded in initiating a process towards collaboration to address urban poverty. They developed (and reached agreement about) a procedure with a form that would be filled in during the intake interview at the foodbank, which would help the aid organisation to get more insight in which possible aspects (other than financial ones) clients could use help in.

Outcome. Our findings show that highlighting with whom students observe and address problems, emphasising the participatory character of their approach and assessment criteria that do not merely focus on the product can contribute to a *mutually shared* outcome.

In cases where students adopted a participatory approach with a diversity of stakeholders, the mutually shared character was often reflected in the outcome. Sometimes students identified more strongly with one stakeholder (group) than with others and incorporated the viewpoints, values or strategic intentions of this stakeholder (group) more in their solutions than the perspectives of others. In Good Life and Urban Health, it was noticeable that some stakeholder perspectives were poorly reflected in the outcomes presented during their final presentations for teachers and stakeholders. The questions from stakeholders in the audience underpinned this. The experience of presenting the (mid-term) outcomes of the problem-solving process for a diverse group of experts (Network Building, Good Life, Urban Health) and stakeholders (Sustainable Cities, Good Life, Urban Health) and the collective reflection

on its value contributed to students' awareness of the importance of a *mutually shared* outcome.

Alignment of problems, problem-solving processes and outcomes

The manifestations of *complexity*, *uncertainty* and *value divergence* in the problems, the problem-solving processes and the outcomes are interrelated. Change in any dimension can lead to an increase or decrease of wickedness. The quality and value of the outcome of the problem-solving process depends on how problem, process and outcome are aligned in a coherent curriculum design, as is also the case for the educational outcome, students' learning. Alignment of the aimed learning outcomes, activities of students and teachers, and the assessment of students' learning is a precondition for the alignment between problem, process and outcome. Our findings show that destructive tension thereby experienced by students may result in risk aversion and uncertainty avoidance, which in turn may lead to a reduction of the wickedness experienced. Teachers should recognise and acknowledge this destructive tension in a timely manner in order to balance it in a coherent curriculum design and restore alignment between problem, process and outcome.

The various procedures and efforts of students and teachers in the courses yielded a large variety of problems, though sometimes with an undesirably high or low level of wickedness. In Urban Health and Sustainable Cities teachers selected commissioners/clients and agreed with them on assignments. In the other courses, the students identified problems and found clients/partners. This had learning potential regarding context analysis and approaching stakeholders, and also implied that teachers relinquished control, as they could only facilitate the search for suitable problems and try to enhance stakeholder engagement.

Assignments and the assessment of students' learning can either support or undermine students' learning and the alignment between problem, process and outcome (Vignette 8). In Good Life, the integral and mutually shared character of the outcome was reflected in quality criteria for the outcome and students needed to find someone willing to adopt their plan for an age-friendly innovation. The problem-solving approaches that were used in the courses encompassed activities/assignments related

Vignette 8 Sustainable Cities: a bar raised too high

In new course Sustainable cities design thinking was used as a problem-solving approach. 'The Comakership is structured through the process of design-oriented research and covers five essential phases (...) for the challenge that is given by the client' (study guide). This approach was new to most students. Moreover, they lacked experience with addressing problems beyond the level of a single company. The students experienced destructive tension. Though this was felt by the teachers, they did not succeed in balancing it. Each phase had fixed deliverables that had to be submitted at set deadlines. This fixed time scheme hindered teachers' strategies of balancing tension, and did not support a transdisciplinary, adaptive and participatory approach. A teacher explained: 'When you make the wrong start, with an assignment that students perceive as too vague, the process remains laborious and difficult. They are too late in getting started, and when they have things up and running, you already want to see their final report, while you would wish them to be able to continue.'

to *understanding* the problem and *generating responses*, such as stakeholder and context analyses, problem statements, research plans, commission contracts, documentaries or future scenarios. However, the purpose of the assignments was not always clear for students and in some cases assessment criteria were perceived as instrumental, also by teachers. Appendix 1 presents an overview of the aimed learning outcomes, assessment (deliverables) and assessment criteria in the courses.

Towards empirically-grounded design principles

Analysis and interpretation of our findings resulted in the following principles for curriculum design.

Problem features

- *Ensure that characteristics of problems that induce wicked tendencies, namely, the systems-like character, change and fragmentation, are present in the problem as experienced by students.*

Given the aim of learning to observe and address problems with *wicked tendencies* and students' vital role in identifying and framing these problems, it is essential that students learn about the concept of wickedness and experience it in its different manifestations in the problems. A micro-level orientation involving real-life contact is favourable in this sense and helps to avoid the sense of vagueness students tend to experience when starting from a meso-/macro-level. Interdisciplinary group composition and the presence and involvement of multiple stakeholders contribute to value divergence related to the problem.

Problem-solving process

- *Ensure that transdisciplinarity, adaptiveness and participation are encouraged during the problem-solving process, in efforts to understand and address the problem.*

The transdisciplinary, adaptive and participatory character of the problem-solving process is encouraged in different ways. Micro-level orientations are helpful in intensifying stakeholder interaction. Changes in scale and focus during the problem-solving process lead to the involvement of different stakeholder groups over time. However, students' avoidance of stakeholder interaction hinders their understanding of the wicked tendencies of the problem, leads to missing important process experiences and compromises a transdisciplinary, adaptive and participatory approach.

Outcome of the problem-solving process

- *Ensure that the integral, provisional and mutual character of the outcome of the problem-solving process is fostered and expected.*

In an aligned approach, the manifestation of wickedness in the outcome of the problem-solving process lies in its being integral, provisional and mutually shared and accepted by the stakeholders. Teachers should emphasise how transdisciplinary approaches contribute to the *integral* character of the outcome, to avoid partial solutions. Setting broad goals that allow for an adaptive approach fosters the *provisional* character of the outcome. Emphasising *with whom* students observe and address problems and the participatory character of the problem-solving process can contribute to a *mutually shared* outcome. It is important to have an open-ended view of the possible types of outcomes. Outcomes should be the result of the two intertwined challenges that students face: understanding the problem and generating responses to the problem.

Constructive tension

- *Create, balance and leverage constructive tension regarding the manifestations of wickedness and ensure that students' coping behaviour in terms of behavioural efforts students in order to reduce destructive tension is recognised by teachers and dealt with.*

Coping strategies as a result of destructive tension, such as avoiding uncertainties, risks and limiting stakeholder contact, lead to a reduction in wickedness experienced, to misalignments in problem, process and outcome and reduce learning potential. Coping behaviour leads to missing important changes in the problem context and compromises a transdisciplinary, adaptive and participatory approach. The transition from understanding the problem to generating responses often triggered an increase in destructive tension. It is important that teachers recognise destructive tension in a timely manner and act upon it, by helping students to develop a positive mindset towards manifestations of wickedness and by reducing the fear of negative evaluations. One strategy that helps teachers to balance and leverage constructive friction is a gradual increase in factors that contribute to the experience of wickedness, such as changes in scale and focus.

Alignment

- *Ensure alignment between problems, problem-solving approaches and outcomes regarding the manifestations of wickedness.*
- *Ensure that this alignment is supported in the formulated learning outcomes and the assessment of students' learning.*

To foster students' learning in addressing wickedness and to enhance the value of the outcome of the process, a suitable problem alone is not enough. It is important to also consider the alignment of problems, problem-solving process and outcome. Consequently, it is important to frame the relation with the main stakeholders and make their roles, responsibilities and participation explicit. The formulation of the aimed learning outcomes and the assessment of students' learning should support this alignment. The assessment of the problem-solving *process* needs to address students' understanding of the problem in its specific context and their responses to the

problem, as well as the extent to which the problem-solving process was transdisciplinary, adaptive and participatory. Assessment of the *outcome* of the problem-solving process generated by students should reflect on its integral, provisional and mutual character.

Conclusion and discussion

This study provides insight into the design of HPE courses preparing students for dealing with different manifestations of wickedness when addressing problems with wicked tendencies in multi-stakeholder or interdisciplinary contexts. It contributes to new insights into how problems, problem-solving approaches and outcomes in HPE courses can be aligned in a coherent curriculum design. We conclude that wickedness, broken down along three dimensions, is manifested in features that create tension when experienced by HPE students. This tension may be destructive, potentially leading to undesired coping behaviour of students attempting to reduce the tension. This in turn can result in a reduction of the experienced wickedness and in misalignments between problem, process and outcome, so that teachers, in turn, must balance the tension in order to restore alignment.

Our study raises two key challenges. The first challenge relates to students' coping behaviour. Wickedness is situated and should be analysed by looking at how it is experienced by students and stakeholders (Noordegraaf *et al.*, 2019). Students experience problems in different ways and have different mindsets towards change, risks and other manifestations of wickedness, resulting in both constructive and destructive tension and in different coping strategies, such as decreasing wickedness by focusing on one particular stakeholder, or treating dynamic problems as if they were static. Following Rittel and Webber (1973), Daviter (2017) referred to this as taming: treating ill-structured problems as tame problems. 'Taming wicked problems accepts that competing problem perspectives are cast aside rather than explored' (p. 579). This can lead to responses that are not integral and ignore interdependencies. Future research could focus on the process of problem-solving in action, and thereby contribute to better insight into the triggers and incentives for students' undesired coping behaviour.

The second challenge relates to how teachers (and educational designers) cope with alignment and its associated dilemmas. Ensuring alignment between problem, process and outcome in a coherent curriculum design and promoting constructive tension is a problem with wicked tendencies itself. Process-oriented teaching practices enable teachers to 'promote congruence and constructive friction, and to avoid destructive friction' with student learning practices (Vermunt & Verloop, 1999, p. 274). According to Brundiers *et al.* (2010), the functions of traditional models of real-world learning concepts are being reconsidered. An example of this is the shift in service learning from, for the community, to, with the community, and the notion of, mutual learning, of the stakeholders involved (p. 311). This is in line with our appeal for a participatory and transdisciplinary problem-solving process and for active stakeholder engagement. Teachers, students and stakeholders had diverging values and interests and used different (coping) strategies to guard their interests, to manage risks and uncertainties and to reach their goals. Teachers experienced uncertainty

owing to the need for mutual commitment and to the dependencies regarding the open-endedness of the problems in the courses and the unpredictability of the outcome of the learning process. Teachers also experienced a high level of complexity, given that the problem cuts across different systems: school, society, professional fields. To manage the tensions and contradictions between deploying wicked tendencies as vehicles for learning and the rules and values of the current HPE system, we must direct our attention and efforts to *enabling* alternative strategies (Termeer *et al.*, 2015). These new strategies should encompass a broader view of outcomes and a more comprehensive view of assessment of the competencies and mindsets that allow for the successful handling of wicked situations (Neubert *et al.*, 2017).

In this study, we looked at educational practices at the course level. However, the wickedness experienced by students is also influenced by the larger educational context of programmes and higher education policies. Livingston *et al.* contend that ‘in an increasingly supercomplex uncertain and unpredictable world, decisions about relevant curriculum content and processes of enactment in schools and classrooms are challenging and contested’ (Livingston *et al.*, 2015, p. 515). Further research could contribute to new insight into how to arrive at integral solutions at the curriculum level. Shifting the focus from *wicked problems* to fostering students’ learning in respect to of the *wicked tendencies of problems* (breaking down wickedness in three dimensions) (Newman & Head, 2017) and understanding wickedness as a *spectrum of difficulties*, as suggested in this study, may be helpful in this endeavour.

Disclosure statement

There are no conflicts of interest to disclose.

Ethics approval statement

All the research meets the ethical guidelines, including adherence to the legal requirements of the Netherlands. The students who participated in this study, gave their informed consent; No material from other sources has been used without permission.

Geolocation information

Almere, The Netherlands; Zwolle, The Netherlands.

References

- Alford, J. & Head, B. W. (2017) Wicked and less wicked problems: A typology and a contingency framework, *Policy and Society*, 36(3), 397–413. <https://doi.org/10.1080/14494035.2017.1361634>
- Anderson, C. & McCune, V. J. (2013) Facing an uncertain future: Curricula of dualities, *Curriculum Journal*, 24(1), 153–168.
- Australian Public Service Commission. (2007) *Tackling wicked problems: A public policy perspective* (Canberra, Australian Public Service Commission).
- Biesta, G. (2009) Good education in an age of measurement: On the need to reconnect with the question of purpose in education, *Educational Assessment, Evaluation and Accountability*, 21(1), 33–46.

- Brundiers, K., Wiek, A. & Redman, C. (2010) Real-world learning opportunities in sustainability: From classroom into the real world, *International Journal of Sustainability in Higher Education*, 11(4), 308–324.
- Conklin, E. J. & Weil, W. (2007) *Wicked problems: Naming the pain in organizations* [White paper]. (Touchstone Consulting Group). Available online at: <http://www.touchstone.com/wp/wicked.html>
- Daviter, F. (2017) Coping, taming or solving: Alternative approaches to the governance of wicked problems, *Policy Studies*, 38(6), 571–588.
- Freeman, R. E. (2010) *Strategic management: A stakeholder perspective* (Cambridge, Cambridge University Press).
- Glicken, J. (2000) Getting stakeholder participation ‘right’: A discussion of participatory processes and possible pitfalls, *Environmental Science & Policy*, 3(6), 305–310. [https://doi.org/10.1016/S1462-9011\(00\)00105-2](https://doi.org/10.1016/S1462-9011(00)00105-2)
- Gulikers, J. & Oonk, C. J. S. (2019) Towards a rubric for stimulating and evaluating sustainable learning, *Sustainability*, 11(4), 969. <https://10.3390/su11040969>
- Head, B. W. (2008) Wicked problems in public policy, *Public Policy*, 3(2), 101–118.
- Head, B. W. (2018) Forty years of wicked problems literature: forging closer links to policy studies, *Policy and Society*, 38(2), 180–197. <https://doi.org/10.1080/14494035.2018.1488797>
- Head, B. W. & Alford, J. (2015) Wicked problems: Implications for public policy and management, *Administration & Society*, 47(6), 711–739. <https://doi.org/10.1177/0095399713481601>
- Head, B. W. & Xiang, W.-N. (2016) Why is an APT approach to wicked problems important? *Landscape and Urban Planning*, 154, 4–7. <https://doi.org/10.1016/j.landurbplan.2016.03.018>
- Hennessy, S. & Murphy, P. (1999) The potential for collaborative problem solving in design and technology, *International Journal of Technology and Design Education*, 9(1), 1–36.
- Koppenjan, J. F. M. & Klijn, E. H. (2004) *Managing uncertainties in networks: a network approach to problem solving and decision making* (London, Routledge).
- Livingston, K., Hayward, L., Higgins, S. & Wyse, D. (2015) Multiple influences on curriculum decisions in a supercomplex world, *Curriculum Journal*, 26(4), 515–517.
- Neubert, J., Lans, T., Mustafic, M., Greiff, S. & Ederer, P. (2017) Complex problem-solving in a changing world: Bridging domain-specific and transversal competence demands in vocational education, in: M. Mulder (Ed) *Competence-based vocational and professional education: Issues, concerns and prospects*, (vol. 23) (Springer), 953–969.
- Newman, J. & Head, B. W. (2017) Wicked tendencies in policy problems: Rethinking the distinction between social and technical problems, *Policy and Society*, 36(3), 414–429. <https://doi.org/10.1080/14494035.2017.1361635>
- Noordegraaf, M., Douglas, S., Geuijen, K. & van der Steen, M. (2019) Weaknesses of wickedness: A critical perspective on wickedness theory, *Policy and Society*, 38(2), 278–297 <https://doi.org/10.1080/14494035.2019.1617970>
- Norton, B. G. (2012) The ways of wickedness: Analyzing messiness with messy tools, *Journal of Agricultural & Environmental Ethics*, 25(4), 447–465. <https://doi.org/10.1007/s10806-011-9333-3>
- Rittel, H. & Webber, M. M. (1973) Dilemmas in a general theory of planning, *Polity*, 4, 155–169.
- Saldaña, J. (2015) *The coding manual for qualitative researchers* (Los Angeles, CA, Sage).
- Scott, J., Penaluna, A. & Thompson, L. J. (2016) A critical perspective on learning outcomes and the effectiveness of experiential approaches in entrepreneurship education: Do we innovate or implement, *Education and Training*, 58(1), 82–93. <https://doi.org/10.1108/ET-06-2014-0063>.
- Simon, H. A. (1973) The structure of ill-structured problems, *Artificial Intelligence*, 4(3), 181–201.
- Termeer, C. J. A. M., Dewulf, A. & Biesbroek, R. (2019) A critical assessment of the wicked problem concept: Relevance and usefulness for policy science and practice, *Policy and Society*, 38(2), 167–179. <https://doi.org/10.1080/14494035.2019.1617971>
- Termeer, C. J. A. M., Dewulf, A., Breeman, G. & Stiller, S. J. (2015) Governance capabilities for dealing wisely with wicked problems, *Administration & Society*, 47(6), 680–710. <https://doi.org/10.1177/0095399712469195>

- Turnbull, N. & Hoppe, R. (2018) Problematizing ‘Wickedness’: A critique of the wicked problems concept, from philosophy to practice, *Policy and Society*, 38(2), 315–337. <https://doi.org/10.1080/14494035.2018.1488796>
- Veltman, M. E., van Keulen, J. & Voogt, J. M. (2019) Design principles for addressing wicked problems through boundary crossing in higher professional education, *Journal of Education and Work*, 32(2), 135–155. <https://doi.org/10.1080/13639080.2019.1610165>
- Vermunt, J. D. & Verloop, N. (1999) Congruence and friction between learning and teaching, *Learning and Instruction*, 9(3), 257–280.
- Voogt, J. M., Pieters, J. M. & Handelzalts, A. (2016) Teacher collaboration in curriculum design teams: Effects, mechanisms, and conditions, *Educational Research and Evaluation*, 22(3–4), 121–140. <https://doi.org/10.1080/13803611.2016.1247725>
- Vygotsky, L. S. (1978) *Mind in society: The Development of higher psychological processes* (Cambridge, MA, Harvard University Press).
- Xiang, W.-N.-J. (2013) Working with wicked problems in socio-ecological systems: Awareness, acceptance, and adaptation, *Landscape and Urban Planning*, 110, 1–4. <https://doi.org/10.1016/j.landurbplan.2012.11.006>
- Yin, R. K. (2014) *Case study research: Design and methods* (5th edn) (Thousand Oaks, CA, Sage Publications).

Appendix 1. An overview of the aimed learning outcomes, assessment (deliverables) and assessment criteria in the courses

Case	Good life	District intervention	Urban health	Network building	Social enterprise	Sustainable cities
Aimed learning outcomes	<i>Week 1-20:</i> Learning goals: The student... (1) explores wishes and needs of elderly people in co-creation with elderly people and other stakeholders; (2) visualises wishes and needs of elderly people in co-creation with elderly people and other stakeholders; (3) interacts in a respectful manner with elderly people and other stakeholders; (4) identifies opportunities serving as a step to renewing and realising age-friendly services; (5) reflects on his/her professional development and on the effect his/her actions have on others	<i>Week 1-10:</i> Learning goals: The student... (1) makes contact with local residents, volunteers and professionals using creative agogics skills; (2) applies the methodical cycle to foster social cohesion, social identity and social equality; (3) forms an understanding of the chosen district, can point out how people live, the quality of living; (4) clarifies situations in a conversation, using communication skills and interview techniques; (5) develops a social map using research skills and having an eye for (in) formal aspects; (6) explores issues regarding citizenship, diversity, poverty, discrimination, integration, emancipation, etcetera; (7) can use observation- and interview techniques, and can understand statistics; (8) makes a connection with theory, searches for professional literature, and assesses its usability; (9) can present outcomes to stakeholders	<i>General</i> (1) Interdisciplinary collaboration in a research project focused on fostering health and/or wellbeing of urban residents (in an integral manner). <i>Knowledge</i> (2) Can explain current health issues: healthy practice, socio-economical health differences, health-related skills and functional illiteracy, a healthy environment and healthy behaviour (including nudging and Environmental Law), administrative base, social marketing, public-private partnerships, prevention, etcetera; (3) can mention the actors who can influence health <i>Personal skills</i> (4) reflects on personal learning goals and competencies; (5) compares the individual qualities with the qualities needed for the different assignments; (6) presents a pitch; (7) recognizes his/her strengths/weaknesses in a multidisciplinary team and the strengths/weaknesses of other people involved (8) shows sufficient initiative	The 'common learning outcomes' of the bachelor programme were used: (1) Consistent: The graduate approaches professional and ethical dilemmas from a global and inclusive perspective in order to translate these issues in terms of demands from people, planet and prosperity; (2) Personal leadership: The graduate has developed a personal and professional identity in order to be an independent career navigator; (3) Innovator: The graduate applies knowledge and skills founded in applied research in (re) development and (re) design of professional services and products in order to improve processes and products and contribute to professional project practices and theories; (4) Connector: The graduate connects perspectives and actors, and communicates between perspectives and actors, in order to manage and lead projects carried out by diverse and multidisciplinary teams. In addition, students had to formulate five personal learning goals based on the Five Minds from Howard Gardner: the disciplined, synthesizing, creating, respectful and ethical mind	<i>Week 1-10:</i> Learning goals: The student... (1) demonstrates and uses knowledge and 'social entrepreneurship' in organisations; (2) uses knowledge and understanding of current corporate social responsibility issues in different sectors, in regard to social entrepreneurship in organisations; (3) presents an idea regarding social entrepreneurship using a business case and the organisation infrastructure <i>Week 11-20:</i> Learning goals: The student... (1) acquires an assignment regarding social entrepreneurship; (2) delineates the assignment; (3) writes an advisory report regarding social entrepreneurship in correct language; (4) learns to manage his/her own progress regarding the assignment; (5) develops professional conduct regarding social entrepreneurship; (6) addresses an authentic issue regarding social entrepreneurship; (7) learns to collaborate in a project	Learning goals: The student... (1) examines the current status of the challenge and develops understanding of the challenge (Comprehension & Analysis); (2) develops a focus and framing to the challenge in order to a specific point of view (Synthesis); (3) identifies several solutions to the challenge and selects the most viable options (Synthesis & Evaluation); (4) designs a prototype of the chosen solution and validates this solution together with the client and/or stakeholders (Synthesis & Evaluation); (5) reflects on his/her role in the group and on the individual learning process and development throughout the process. (Evaluation)
	<i>Week 21-40:</i> Integrated learning outcome: The student designs and realises an underpinned business case/proposal for a age-friendly service, suitable for a semi complex context and the underlying aging-related issue in co-creation with elderly people and other stakeholders	<i>Week 11-20:</i> Learning goals: The student... (1) applies the methodical cycle to foster social cohesion; (2) assesses the social cohesion in the district and designs an intervention/activity to foster social cohesion; (3) explores issues regarding social cohesion; (4) compares different views regarding social cohesion; (5) is aware of the advantages of an entrepreneurial attitude while working in the district; (6) uses client-centred thinking and looks at opportunities and limitations at the organisational level; (7) considers money, organisation, quality, information, time; (8) recognizes ethical issues and takes ethical decisions; (9) develops a sensitivity for diversity when taking ethical decisions and practices with arguments and formulations; (10) presents the outcome in a professional manner; (11) designs and underpins an intervention using the methodical cycle and theory; (12) justifies (methodical) choices; (13) describes which image of the human being and which theories underpin the chosen intervention/approach	<i>Research project</i> (9) describes and substantiates the background for the health issue; (10) conducts a problem analysis; (11) applies research skills and methods in an integral assignment; (12) Analyses and processes data; (13) writes a professional report; (14) specifies and addresses issues that foster multidisciplinary collaboration; (15) project-based working in a research project; (16) designs deliverables on bachelor level; (17) designs all deliverables with care; (18) develops a deliverable that meets the wishes of the commissioner; (19) maintains good contact with the commissioner; (20) takes the wishes of end users into account during the process; (21) promotes a professional work atmosphere in the project team; (22) awareness of the context and the influence of the context on the process and its outcome			(Continues)

Appendix 1. (Continued)

Case	Good life	District intervention	Urban health	Network building	Social enterprise	Sustainable cities
Assessment (deliverables)	<p><i>Week 1-20:</i></p> <ol style="list-style-type: none"> 1. Future scenario (incl. account of the research) (S, G, 33,3%) 2. Visual presentation (S, G, 3,3%) 3. Learning report (S, I, 33,3%) <p><i>Week 21-40:</i></p> <ol style="list-style-type: none"> 1. Plan (F, G) 2. Journal and mid-term learning report (F, I, G) (S, G, 25%) 3. Business case/proposal (S, G, 25%) 4. Implementation plan (S, G, 25%) 5. Presentation at final symposium (S, G, 25%) 6. Learning report (individual reflection on learning outcomes and team reflection on collaboration (S, I, G 25%) 	<p><i>Week 1-10:</i></p> <ol style="list-style-type: none"> 1. Documentary (S, G) 2. Accountability/reflection report (S, G) 3. Accountability/reflection report (S, I) <p><i>Week 11-20:</i></p> <ol style="list-style-type: none"> 1. Accountability report choice of problem (S, G) 2. Intervention plan (S, G) 3. Presentations (1 for district, one for school) (S, G) 4. Accountability/reflection report (S, I) <p>Weighting was not specified in available documents</p>	<ol style="list-style-type: none"> 1. Communication plan (F, G) 2. Plan (F, G) 3. Pitch (S, G, 5%) 4. Final report research project (S, G, 60%) 5. Reflection report (S, I, 25%) 6. Final presentation research project (S, G, 10%) 	<ol style="list-style-type: none"> 1. Value product (S, G, 50%) assessed by the coordinator and a jury of professionals 2. Case study (S, G, 25%) 3. Self assessment (S, I, 25%) 	<p><i>Week 1-10:</i></p> <ol style="list-style-type: none"> 1. Presence at challenge days (C, D) 2. Essay (I, S, 100%) <p>Design process:</p> <ol style="list-style-type: none"> a. Point of View + Design Criteria b. Understanding the challenge c. Ideation on possible solutions d. Prototyping e. Validation <p><i>Week 11-20:</i></p> <ol style="list-style-type: none"> 1. Advisory report (including an action) (S, G, 100%) 2. Final presentation (G, C) 	<ol style="list-style-type: none"> 1. Portfolio including all mandatory deliverables throughout the design process (S, G, 80%) <p>Design process:</p> <ol style="list-style-type: none"> a. Point of View + Design Criteria b. Understanding the challenge c. Ideation on possible solutions d. Prototyping e. Validation <ol style="list-style-type: none"> 2. Reflection report (present the concept plus portfolio to the client and reflect on your own individual process throughout the course) (S, I, 20%)
Examples of assessment criteria related to the manifestations of wickedness in problem, process or outcome	<p>Uncertainty (<i>change</i>):</p> <ul style="list-style-type: none"> • The advice demonstrates insight in different trends that influence the future scenario 	<p><i>Documentary</i></p> <p>Complexity (<i>systems</i>)</p> <ul style="list-style-type: none"> • The issues (positive and negative) in the district, as experienced by people, as well as the related factors and causes, are clearly addressed. 	<p>Complexity</p> <ul style="list-style-type: none"> • There is a full and clear description of the problem, the problem context and the current situation 	<p><i>E-model</i></p> <p>Complexity (<i>systems</i>)</p> <ul style="list-style-type: none"> • The report and/or product provides a relevant visualization of the network(s) 	<p>The learning goals were used as assessment criteria:</p> <p>Complexity/</p> <p>Fragmentation: Demonstrates and uses knowledge and understanding of 'social entrepreneurship' in organisations'</p> <ul style="list-style-type: none"> • The student uses knowledge and understanding of current corporate social responsibility issues in different sectors, in regard to social entrepreneurship in organisations 	<p><i>Validation</i></p> <p>Uncertainty (<i>change, provisional</i>)</p> <ul style="list-style-type: none"> • The underlying assumptions to the concept/prototype are described in detail and ranked in terms of risk and impact. The most important (riskiest) assumptions are described in detail

(Continues)

Appendix 1. (Continued)

Case	Good life	District intervention	Urban health	Network building	Social enterprise	Sustainable cities
	Fragmentation (<i>participative</i>): <ul style="list-style-type: none">Learning report: The student has explored and visualized the wishes and needs of elderly people in co-creation with elderly people and other stakeholders. This is reflected in the students' contribution to:<ul style="list-style-type: none">a Good collaborationb Equal contribution of all partnersc Pointing out the (desired) outcome of co-creation.	Complexity (<i>transdisciplinary</i>) <ul style="list-style-type: none">Information has been collected from multiple sources and has been critically assessed	Complexity/fragmentation <ul style="list-style-type: none">The relevance for addressing the problem has been underpinned with multiple arguments, on the macro-level and/or from different perspectives.The connection between the different actors and their meaning in the context of the problem has been explored.Use has been made of the most relevant/different perspectives and (international) sources	Uncertainty/fragmentation <ul style="list-style-type: none">There is a clear description of the learning process within the network(s), that is, getting, giving and using feedback within these relationships. The description also delineates the specific role of the network(s)	Social enterprise	Fragmentation (<i>participative, mutually shared</i>) <ul style="list-style-type: none">The underlying assumptions to the concept/prototype are validated extensively with the customer/ client. The provided feedback is described in detail
	Fragmentation (<i>mutually-shared</i>): <ul style="list-style-type: none">The aimed future scenario is demonstrably based on the questions/wishes/needs of the elderly people	Fragmentation (<i>fragmentation, participative</i>) <ul style="list-style-type: none">Multiple visions are addressed/included: a diversity of residents with different backgrounds and opinions, as well as different professionals from organisations/institutionsThe different perspectives are treated with respect	Fragmentation (<i>mutually-shared</i>): <ul style="list-style-type: none">The wishes and preferences of end users have been considered during the design of the productsIt becomes clear that the support for this solution has been explored	Complexity/fragmentation <ul style="list-style-type: none">The E-model report clearly articulates which network(s) or community relationships were cultivated and formed during the process and this is reflected in the final productThere is a clear description of how the product advances the network(s) or community's practices, strategies or activities (in relation to the issue)The contribution of stakeholders to value creation and expected outcomes is clearly identified, that is, who contributed what?	Social enterprise	Fragmentation (<i>participative, mutually shared</i>) <ul style="list-style-type: none">The underlying assumptions to the concept/prototype are validated extensively with the customer/ client. The provided feedback is described in detail

G = group level; I = individual level; C = conditional (not graded); F = formative; S = summative; % = weighting factor for final grade.