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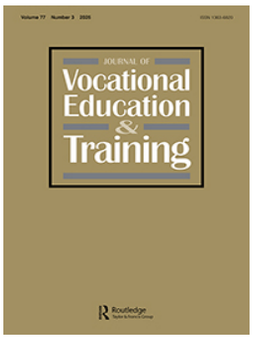

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Examining student profiles for dealing with wickedness

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ABSTRACT

When addressing problems with wicked tendencies in higher professional education, students experience complexity, uncertainty, and value divergence. Furthermore, they are confronted with disciplinary, organisational, and sector boundaries. Prior research has revealed variability in students' experiences and boundary-crossing behaviour when dealing with problems with wicked tendencies. In this study we explore these differences by identifying student profiles based on the attributes that comprise the competence for dealing with problems with wicked tendencies, and by identifying their relations with students' boundary-crossing behaviour and relevant work experience. Person-centred cluster analysis in a sample of first-year students ($N = 264$) from a bachelor's programme in social work identified four student profiles, based on students' self-assessed degree of creativity, critical thinking, initiative, proactivity, risk tolerance, and work efficacy. Meaningful relations with students' prior work experiences and their boundary-crossing behaviour were found. These profiles could serve to better understand students' boundary-crossing behaviour when confronted with problems with wicked tendencies, and help teachers foster the development of all students.

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student profiles; problem-solving competence; boundary crossing; teacher strategies; higher education; wicked problems

Introduction

Students today face a world in transition. Complex and ill-defined problems, such as social equity, ageing populations, and poverty, which transcend disciplinary, organisational, and sector boundaries (Head and Alford 2015), reshape the demands placed on professionals. Professionals are expected to contribute to joint efforts aimed at addressing these problems in dynamic and unpredictable contexts, while facing ambiguities and navigating uncertainty, complexity, and value divergence (Noordegraaf 2007). The increase in interprofessional

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work across various contexts has led to shifts and expansions of professional roles, and to experiences of vagueness and role conflict (Noordegraaf 2007). The ability to benefit from the expertise of others has become as vital as having specific domain expertise (Noordegraaf 2007; Penttilä and Kairisto-Mertanen 2013). Building upon the notion of boundary-crossing: the processes of working and learning extend beyond the mere acquisition of expertise within a confined domain. They encompass crossing boundaries in the sense of entering unfamiliar grounds and combining elements of different contexts to create new solutions or knowledge (Akkerman and Bakker 2011).

Higher professional education (HPE) aims to prepare students for the evolving roles and practices that professionals encounter when navigating these challenges (Neubert et al. 2017; Smith, Shaw, and Tredinnick 2015). This is reflected in the increase in authentic learning environments, wherein students address problems with wicked tendencies in collaboration with external stakeholders across organisational and disciplinary boundaries (Penttilä and Kairisto-Mertanen 2013; Veltman, Van Keulen, and Voogt 2021). These settings immerse students in new and unpredictable situations, encouraging them to take risks and explore different perspectives. Prior research has highlighted variability in how students experience uncertainty, complexity, and value divergence when addressing problems with wicked tendencies in HPE courses (Veltman, Van Keulen, and Voogt 2019, 2021, 2022). That variability manifests as differences in boundary-crossing behaviour (Gulikers and Oonk 2019), different degrees of tension (Veltman, Van Keulen, and Voogt 2021), and diverse coping mechanisms, such as avoiding interaction with stakeholders (Şeremet, Haigh, and Cihangir 2021).

From a situated, people-centred perspective on wickedness, how people experience wickedness, cope with it, and pay attention to it, as well as the attributes at their disposal to do so, also varies (Noordegraaf et al. 2019). When viewed from an integrated stance, as proposed by Hager (2017) and Funke, Fischer, and Holt (2018), among others, the competence to deal with wickedness entails a combination of both cognitive and non-cognitive attributes. These attributes encompass knowledge, skills, abilities, and attitudes needed to address the challenges of observing wickedness and taking joint action in the context of wickedness (Termeer et al. 2015). Several studies have stressed the influence of personal attributes, such as risk tolerance, on people's learning and behaviour in collaborative and open-ended problem solving (Da Silva and Davis 2011; Head 2019; Head and Xiang 2016).

A better understanding of the differences between students is important to inform teachers' strategies and foster each student's learning. More insight is needed into the influence of students' personal attributes on their boundary-crossing behaviour when learning to deal with wickedness (Arenas, Tabernero, and Briones 2006; Hero, Lindfors, and Taatila 2017) and the relation of these attributes with prior relevant work

experience (Bhandari et al. 2021). Therefore, this study investigates which combinations of attributes that comprise the competence for dealing with problems with wicked tendencies exist in a sample of social-work students in a first-year course situated in the local community. We use person-centred cluster-analysis to investigate whether different student profiles with respect to self-reported attributes for dealing with wickedness can be identified. Subsequently, we examine how students' self-reported boundary-crossing behaviour and relevant work experience are related to their profile assignments.

Learning in contexts of wickedness

In 1973, Rittel and Webber introduced the term *wicked problems* to describe a category of complex social problems characterised by ill-definedness, ambiguity, multi-dimensionality, open-endedness, resistance to solutions, and differences in the values and perspectives of the people involved (Rittel and Webber 1973). Following Head (2008) and Head and Alford (2015), we understand wickedness as the combination of three dimensions: complexity, uncertainty, and value divergence. *Complexity* refers to the system-like character of problems and the existence of elements, subsystems, and interdependencies. *Uncertainty* concerns the risks, consequences of actions, and changing patterns with respect to conditions or resources that occur over time. *Value divergence* refers to the involvement of stakeholders with diverging perceptions, viewpoints, values, and strategic intentions.

Rittel and Webber's original distinction between wicked problems and 'tame', technical problems (Head 2019), assumed a binary relationship between them. However, currently, wickedness is considered as a spectrum of difficulties (Newman and Head 2017). This perspective acknowledges that problems can vary in the extend of their wickedness, meaning that they can exhibit varying degrees of complexity, uncertainty, and value divergence (Head 2008; Head and Alford 2015). As a result, rather than categorising problems as 'wicked' or not, we refer to problems as having 'wicked tendencies', recognising the varying degrees of wickedness they may exhibit.

When addressing wickedness, people face the two intertwined challenges of observing and understanding the problem, and generating responses in terms of action strategies (Head and Xiang 2016; Termeer et al. 2015). Addressing wickedness requires adaptive, non-routine, experimental, collaborative, participatory and cross-disciplinary approaches (Head 2019; Head and Xiang 2016). Personal attributes, such as people's tolerance for risk and failure, and openness to different perspectives and change influence their perceptions of wickedness, as well as their approaches to dealing with it (Head and Xiang 2016).

Attributes for dealing with wickedness

Following Funke, Fischer, and Holt (2018), Gonczi (2003), and Hager (2017), we adopt an integrated conception of competence. In this conception, competence is understood in terms of a collection of attributes, (i.e. combinations of knowledge, abilities, skills, attitudes, and values) displayed in relation to tasks and challenges in a given context. Funke, Fischer, and Holt (2018) viewed problem-solving competence for complexity as 'a bundle of skills, knowledge and abilities that are required to deal effectively with complex and dynamic non-routine situations in different domains' (42).

The competence for addressing problems with wicked tendencies, in this integrated view, is considered a *relational* concept, since it links tasks and the attributes that are resources for competent performance of these tasks, and emphasises the contextuality of performance (Hager 2017). Hager spoke of '*a contextualized capability involving an integration of assorted practitioner attributes*' (Hager 2017, 206) [italicised in original]. Furthermore, it is a *formative* construct, in the sense that successful performance in situations marked by wickedness can result from various factors, that is, different combinations of cognitive and non-cognitive attributes, including domain-specific and generic attributes (Funke, Fischer, and Holt 2018). This is relevant in the context of addressing problems with wicked tendencies, for which no single approach exists, and which benefit from a diversity of attributes and resources of problem solvers (Guile and Unwin 2020).

Viewing dealing with wickedness as a competence emphasises that the attributes comprising this competence can be developed to varying degrees (e.g. through training) and can change over time (Funke, Fischer, and Holt 2018). Attributes for addressing wickedness can also be shaped by (work) experience. The experiences with manifestations of wickedness that people gain throughout their working life and education can increase their risk tolerance (Bhandari et al. 2021; Karakowsky and Elangovan 2001), for example. As people acquire new skills and become familiar with new contexts and situations, the initial impact of the confrontation with wickedness and risks on their performance tends to diminish (Arenas, Tabernero, and Briones 2006). Additionally, it is important to consider that personal attributes play a vital role in people's engagement in new learning opportunities (Deakin Crick and Goldspink 2014) when addressing wicked challenges.

Another feature of the integrated conception of competence is its *holism*, in the sense that tasks and challenges are not independent and require problem solvers to have a situational understanding (Chatenier et al. 2010; Gonczi 2003; Hager 2017). In addition to task overlap, scholars have also emphasised overlap or amalgamation of the different attributes constituting competence (Avvisati, Jacotin, and Vincent-Lancrin 2013; Gonczi 2003). Attributes widely acknowledged for their importance in dealing with wickedness include creativity, critical thinking,

initiative, proactivity, risk tolerance, and (work) efficacy. Taking into account their intricate intertwining and overlap, and without claiming to be exhaustive, we consider these six attributes to be relevant for dealing with wickedness.

Creativity

Addressing complex, ill-defined, ambiguous, and open-ended problems requires Creativity (Rychen and Salganik 2001; Smith, Shaw, and Tredinnick 2015). Amabile (1996) defined Creativity as the production of novel and useful ideas or solutions. Several scholars have emphasised the influence of Creativity and non-linear thinking on the problem-solving process in relation to finding diverse ways of framing (e.g. Grohs et al. 2018), adopting views from different perspectives (Chatenier et al. 2010; Hero, Lindfors, and Taatila 2017), and dealing with constraints, such as lack of resources and time pressure, commonly faced when dealing with problems with wicked tendencies (Amabile 1996; Rosso 2014).

Critical thinking

The complexity, ambiguous nature, uncertainty, and multiple perspectives of problems with wicked tendencies requires Critical Thinking, beyond fact-finding and evidence-based practice. It also requires Critical Thinking as far as reflective judgement, metacognitive processes, the consideration of multiple perspectives (Milner and Wolfer 2021), relating issues to personal norms and values and/or to general principles (e.g. social justice), and the propensity to participate critically in social practices (Ten Dam and Volman 2004).

Initiative

Opportunity seeking/creation and the tendency to do things without external prompting are considered key features of Initiative (Santandreu-Mascarell, Garzon, and Knorr 2013). Initiative is also considered part of an entrepreneurial mindset (Pihie and Sani 2009). In the context of dealing with wickedness, a person's sense of Initiative also refers to the tendency to contribute by trying new things and engaging in experimentation (Hero, Lindfors, and Taatila 2017). Furthermore, Initiative includes the propensity to persuade and involve others in identified opportunities and initiatives during the problem-solving process (M. M. Keinänen and Kairisto-Mertanen 2019).

Proactivity

Chatenier et al. (2010) stressed the importance of personal Proactivity and intuition in the context of addressing non-routine problems and referred to it as *future orientation*. Bateman and Crant (1993) defined Proactivity as the tendency to effect change. Proactivity is change/development-oriented, self-starting, and future-focused (Tornau and Frese 2013). Proactive people tend to actively search and take advantage of opportunities for improving themselves and their work

processes (Bateman and Crant 1993) by seeking feedback, an asset in contexts marked by uncertainty and ambiguity (Ashford and Cummings 1985).

Risk tolerance

Risk Tolerance is an important attribute for dealing with the uncertainty, ambiguity, dynamics, and constraints in diverse stakeholder contexts characterising problems with wicked tendencies and innovation processes (Caratozzolo, Alvarez-Delgado, and Hosseini 2020). Keinänen and Kairisto-Mertanen (2019) related Risk Tolerance to daring to seize opportunities gained through competence. People with high Risk Tolerance have a propensity take risks (Caratozzolo, Alvarez-Delgado, and Hosseini 2020). A positive orientation towards risk and failure can enhance learning, as they offer valuable potential for learning (Arenas, Tabernero, and Briones 2006; Deakin Crick and Goldspink 2014).

Work efficacy

When lacking clarity and concrete guidelines, people must find ways to deal with constraints and engage in open-ended, adaptive problem-solving approaches (Head and Xiang 2016; Rosso 2014). Work Efficacy, or the belief in one's work-related capabilities (Odello, Hill, and Gómez 2008), is associated with the self-direction and independence needed to promote change and vary approaches (Santandreu-Mascarell, Garzon, and Knorr 2013). When people can perform their work and tasks routinely, they often have more mental space, enabling them to be flexible, improvise, and embrace new experiences and alternative approaches (Butter and van Beest 2017; Chatenier et al. 2010).

Boundary-crossing behaviour

To characterise students' learning in the context of addressing problems with wicked tendencies, we employ the concept of boundary crossing, which is an integral part of the third generation of Cultural Historical Activity Theory (CHAT). When students address problems with wicked tendencies in multi-stakeholder contexts, their learning and activities inherently involve crossing boundaries extending beyond the specific bachelor's programme that they are trained for. This entails entering unfamiliar grounds (Suchman 1994) and combining elements of different contexts to create new solutions or knowledge (Akkerman and Bakker 2011; Engeström, Engeström, and Kärkkäinen 1995).

Boundary crossing is defined by Akkerman and Bakker as 'a process of establishing continuity in a situation of sociocultural difference' (Akkerman and Bakker 2011, 152), referring to the (inter)actions of individuals/groups from different practices at the experienced boundaries, and to the participation of a person in multiple practices (Akkerman and Bruining 2016). Tensions experienced by students when confronted with manifestations of wickedness often point to such boundaries. Crossing boundaries, in the form of *contradictions between different activity systems*,

affords vital opportunities for innovation, change, development, and problem solving (Roth and Lee 2007; Termeer et al. 2015), as well as learning (Wenger 2000). Combining the different viewpoints, attributes, and experiences of different actors (e.g. commissioners, residents, clients, representatives of organisations/businesses/governments) can yield creative ideas, new viable solutions (Penttilä and Kairisto-Mertanen 2013), and new activity-systems (Engeström, Engeström, and Kärkkäinen 1995). However, boundaries are also sources of potential difficulties when students do not manage to cross them.

Akkerman and Bakker (2011) identified four dialogical learning mechanisms through which boundary crossing can take place. *Identification* refers to learning about practices in relation to one another and understanding similarities and differences. *Reflection* entails understanding and making sense of the activities and perspectives of others, which in turn inform and provide context for one's own activities. Reflection results in an expanded set of perspectives that can inform boundary work and lead to mutual meaning-making. *Coordination* is about overcoming boundaries and resolving discontinuities by facilitating movement and effective collaboration between practices. *Transformation* leads to profound changes in practices or new (in-between) practices. When practices are created or changed and mediating tools are generated, new contradictions and other discontinuities are generated. Learning takes place through the continual resolution of discontinuities and contradictions by the actors involved (Akkerman and Bakker 2011) and contributes to the joint problem-solving process.

Present study

This study is part of a larger research project, which adopted a qualitative approach and focused on generating insights to inform the curriculum design of educational practices that foster students' boundary-crossing learning when addressing problems with wicked tendencies, and informing teacher strategies for fostering students' learning during implementation (Veltman, Van Keulen, and Voogt 2019, 2021, 2022). In our previous studies, undertaken in the same educational context, we found diverse experiences of students when confronting challenges posed by problems with wicked tendencies in HPE courses, and observed variability in students' boundary-crossing behaviour (Veltman, Van Keulen, and Voogt 2019, 2021, 2022). A nuanced understanding of how individual attributes influence the navigation of wickedness is needed.

The aim of this study is to provide more insight into the differences in students' attributes related to dealing with wickedness. Given this aim, a quantitative approach at the individual student level has been adopted. From a situated, people-centred perspective on wickedness, it is evident that not only do individuals experience and cope with wickedness differently, but their attention to such situations and the attributes they employ in doing so also exhibit significant

variations (Noordegraaf et al. 2019). Recognising these differences is important for informing effective teaching strategies and fostering each student's learning.

We investigated what student profiles can be identified based on how students self-assess their status on attributes related to addressing problems with wicked tendencies in multi-stakeholder settings. Additionally, we collected data on students' Boundary-crossing Behaviour and Relevant Work Experience to explore whether the different profiles are related to these variables.

The student profiles might help identify and refine how HPE students engaged in addressing problems with wicked tendencies in multi-stakeholder settings can be supported by their teachers. Therefore, we formulated the following research questions:

(1) What student profiles can be identified based on students' attributes regarding addressing problems with wicked tendencies in multi-stakeholder settings?
(2) How are students' boundary-crossing behaviour and relevant work experience related to the profiles?

Figure 1 presents a visual representation of our conceptual frame in relation to the research questions.

Methods

Participants and procedure

This study was conducted with first-year students in the bachelor's programme in social work at an HPE institute (i.e. University of Applied Sciences) in the Netherlands, enrolled in a mandatory, one-semester 10 European Credit

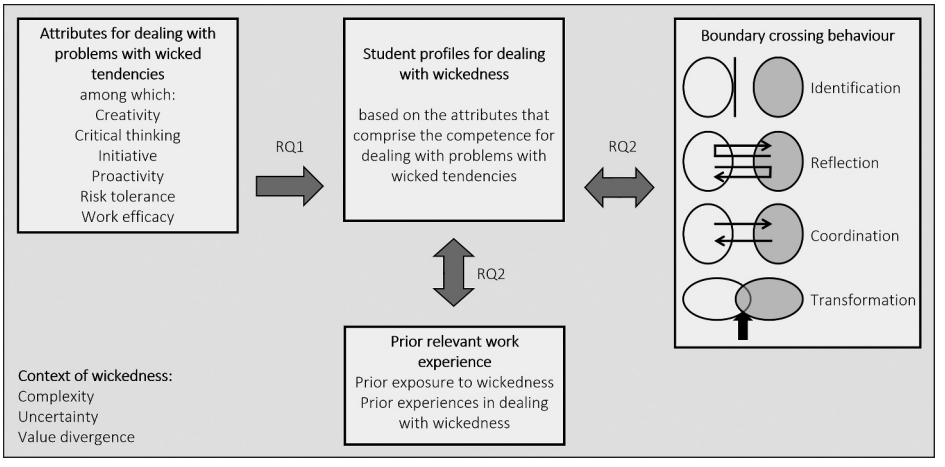

Figure 1. Visualisation of the conceptual frame of the study in relation to the research questions.

module. The module involved addressing authentic problems with wicked tendencies across disciplinary and organisational boundaries at the community/district-level. Students worked in groups of four to six. Each group was tasked with conducting a district-level analysis, identifying a problem, and developing a district-level intervention addressing this problem. The problem contexts involved different stakeholders (e.g. public/private parties, intermediaries, residents).

During the module, a self-assessment questionnaire was administered to the cohort of approximately 450 students in 21 parallel classes via a link in the student manual. Participation was optional, but encouraged. After a brief online introduction and giving informed consent, students were directed to the questions. The questionnaire yielded 276 responses, a response rate of 61%.

After data preparation, the final sample included 264 participants. Information about students' gender, age, prior education, and relevant work experience is summarised in Table 1.

Instruments

In addition to six attribute scales (Creativity, Critical Thinking, Initiative, Proactivity, Risk Tolerance, and Work Efficacy) used in the cluster analysis, the questionnaire included a scale on Boundary-crossing Behaviour and single variables regarding students' Relevant Work Experience and demographic characteristics. Internal consistency of the scales ranged from satisfactory ($\alpha = 0.71$) to good ($\alpha = 0.82$).

Attribute scales

The European FINCODA-project generated scales that measure competences for innovation. Though not explicitly stated, they align well with wickedness theory. The open-ended process of innovation in collaboration with multiple stakeholders is closely tied to addressing problems with wicked tendencies.

Creativity, Critical Thinking, and Initiative were measured using scales from the psychometrically validated FINCODA Barometer (Butter and van

Table 1. Students' age, gender, prior education and relevant work experience ($N = 264$).

Gender	N	Age	N	Prior Education	N	Years of Relevant Work Experience	N
Male	55	17–18	68	Secondary education	125	0	189
Female	205	19–20	108	Vocational education	136	1	30
Other/Not specified	4	21–22	60	Other	3	2	18
		23–24	18			3	18
		≥25	10			4	3
						≥5	6

Beest 2017), a formative online self-assessment tool for both students and professionals. The scales were derived from a systematic literature review (Marin-Garcia et al. 2016). Content validity was assured through workshops with academic/business partners, specialists, and employers, assessing the practical suitability and clarity of the scales. The scales have demonstrated reliability in previous studies (Keinänen and Butter 2018; Keinänen and Kairisto-Mertanen 2019). All items started with 'To benefit innovation, how do you consider your ability to . . . .' and were scored on a 5-point Likert scale ranging from (1) poor to (5) excellent, with an extra option (6) cannot judge. Participants were asked to judge themselves through the eyes of a *competent beholder* ('Think of someone who has a view of your skills. Judge yourself from their perspective').

Creativity. (9 items, $\alpha = 0.81$) measures students' tendency to think beyond existing ideas, rules, patterns, or relationships, and to generate meaningful alternatives, ideas, products, methods, or services independent of their practicality and future added value. Example items are: 'think differently and adopt different perspectives' and 'find new ways to implement ideas.'

Critical thinking. (5 items, $\alpha = 0.76$) measures students' tendency to analyse and evaluate advantages and disadvantages and estimate the risks involved for a given purpose. Example items are: 'forecast impact on users' and 'face the task from different points of view.' One item of the original six items in the scale was excluded from the analysis because the missing values exceeded 10% of the cases. This decision was made to ensure the robustness of the data and maintain the integrity of the scale. The remaining items were retained for analysis, and the reliability coefficient ($\alpha = 0.76$) was calculated based on the retained items.

Initiative. (6 items, $\alpha = 0.82$) measures students' tendency to influence or make decisions that foster positive changes. Example items are: 'go beyond expectations in the assignment, task, or job description without being asked' and 'convince people to support an innovative idea.'

Proactivity, Risk Tolerance, and Work Efficacy were measured with scales from the FINCODA Self Reports, which were used in the mixed-methods validation procedure for the FINCODA Barometer. They were derived from the literature and were practically validated in a workshop with professionals and practitioners (Butter and van Beest 2015, 2017). Participants were asked to judge themselves through the eyes of a competent beholder. All items started with the phrase 'Someone with a view on my skills, will say that I am someone who . . . ' and were scored on a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree.

Proactivity. (8 items, $\alpha = 0.79$) measures students' tendency to search for ways to improve, to learn and see opportunities. Example items are: 'can improve themselves' and 'regularly asks others for feedback on what they are involved with.'

Risk tolerance. (3 items, $\alpha = 0.82$) measures students' propensity to take risks. Example items are: 'takes risks in order to be innovative' and 'likes to take a challenge, even if it's a risk for the company/organisation.' To improve reliability (i.e. from $\alpha = 0.70$ to $\alpha = 0.82$), four of the original seven items were removed.

Work efficacy. The combined scale *Freedom/Autonomy* (4 items, $\alpha = 0.71$) was used to measure students' Work Efficacy. People who feel the freedom to take on new tasks or do their work in a different way are more likely to demonstrate innovative behaviour. People who have a feeling of autonomy are more likely to pursue non-traditional paths. These feelings often stem from the mental space that people experience when they feel competent in doing their tasks and work (Butter and van Beest 2015, 2017). Example items are: 'someone who thinks they are good at their work' and 'someone who feels freedom to pick up new things as part of their job responsibilities.'

Boundary-crossing behavioural scale

Perceived Boundary-crossing Behaviour was measured by the Boundary-crossing Rubric (11 items, $\alpha = 0.76$; Gulikers and Oonk 2016, 2019), designed as an instrument for designing, stimulating, and/or assessing student learning. This instrument had its development rooted in boundary-crossing theory and aligns with a CHAT perspective (Engeström 1987). Observations of authentic learning environments engaging students in complex, transdisciplinary issues, and conversations with teachers actively involved in learning further informed its design. In several iterations, it was tested and validated through workshops involving teachers with diverse experiences in authentic, multi-stakeholder projects. This process aimed to ensure its universal applicability in authentic multi-stakeholder learning processes, regardless of the specific content issue being addressed (Gulikers and Oonk 2016).

In this rubric, the four boundary-crossing learning mechanics of Akkerman and Bakker (2011) are operationalised in terms of four levels of observable student behaviour in relation to student-stakeholder interaction when addressing problems in regional learning environments (Gulikers and Oonk 2019). Example items are: 'Integration of different perspectives, interests, or expertise in a final product' (transformation) and 'Stimulating others to learn' (reflection). While this approach of measuring learning mechanisms may differ from the traditional CHAT perspective (Engeström 1987), in which usually qualitative approaches are followed, it aligns with our specific research questions and the

need for a nuanced examination of the relation between students' attributes and their perceived boundary crossing behaviour.

Relevant work experience

Relevant Work Experience was measured by asking for the 'years of Relevant Work Experience for your current Bachelor programme'. Answer options ranged from: 0 to 5 years or more. A response of 0 years was interpreted as No Relevant Work Experience and responses of 1 through 5 years or more were interpreted as Yes Relevant Work Experience in the analyses.

Data preparation

The answer option 'cannot judge' in the FINCODA Barometer scales (Creativity, Critical Thinking, Initiative) was considered a missing value. Missing value analysis in SPSS was performed to identify patterns. Missing values for one Critical-Thinking item exceeded 10% of cases, so the item was removed (Young, Weckman, and Holland 2011). After removal of all (eight) cases missing more than one value per scale, Little's MCAR test was applied, with outcomes (Creativity: $p = 0.076$; Critical Thinking: $p = 0.204$; Initiative: p=0.268) suggesting that using imputation to address the missing data was appropriate (Little 1988). The iterative expectation-maximisation (EM) algorithm procedure that produces maximum likelihood estimates (Young, Weckman, and Holland 2011) was used to impute the missing data.

Furthermore, prior to running the analyses, four univariate outliers (i.e. values more than 3 *SD* below or above the mean) were removed; no multivariate outliers (i.e. individuals with high Mahalanobis distance values) were found (Leys et al. 2019). This resulted in a total sample of 264 participants.

Analyses

To identify student profiles based on the attributes making up the competence for dealing with problems with wicked tendencies, we evaluated to what extent participants ($N = 264$) scored similarly or differently on the attribute scales, by conducting a cluster analysis. For this analysis we used the Z-scores of the unweighted average scores (Gore 2000) on the six attribute scales. Hierarchical and follow-up *k*-means cluster analysis was conducted using SPSS 28.0.1.0.

Hierarchical cluster analysis was conducted to identify the number of potential clusters in the data, using Ward's linkage and squared Euclidean distance measure. Additionally, the Caliński-Harabasz index value, also called the variance-ration criterion (VRC), was calculated to evaluate the optimal number of clusters for the data. Since the VRC usually decreases with more clusters, the relative loss of variance explained by using fewer clusters (ω) was also

calculated. The optimal number of clusters is the solution with the highest VRC and the lowest ω (Caliński and Harabasz 1974).

Subsequently *k*-means cluster analysis was conducted to identify student profiles based on their attributes regarding addressing problems with wicked tendencies. To ensure a stable cluster solution, multiple *k*-means analyses were performed with variations in the ordering of objects. A univariate analysis of variance (one-way ANOVA) was used to explore significant differences in students' attributes between the clusters. Another one-way ANOVA was performed with the behavioural scale. Finally, chi-square tests were performed for Relevant Work Experience.

Findings

Composition of the clusters

The first research question asked *what student profiles can be identified based on students' attributes regarding addressing problems with wicked tendencies in multi-stakeholder settings*. Inspection of the dendrogram and the agglomeration schedule for the hierarchical cluster analysis indicated the suitability of a three- or four-cluster solution. The VRCs of a three- or four-cluster solution were relatively similar ($VRC_3 = 593.263$; $VRC_4 = 532.422$). The ω was lower for the four-cluster solution ($\omega_3 = 202.503$, $\omega_4 = -24.705$), suggesting that four is the optimal number of clusters for our dataset. Subsequently, multiple *k*-means cluster analyses with three and four clusters were performed. While the *k*-means algorithm did not converge towards an optimal solution for a three-cluster solution, the analyses showed a stable four-cluster solution (convergence was achieved in five iterations). Hence, we proceeded with the four-cluster solution as the final cluster solution (see Figure 2). There were 73 students (27.7%) in Cluster 1, 85 students (32.2%) in Cluster 2, 77 students (29.2%) in Cluster 3, and 29 (11.0%) in Cluster 4.

Differences between the clusters

To confirm significant differences in students' attributes among the clusters, we conducted a one-way ANOVA, using each participant's cluster assignment as the grouping variable. The one-way ANOVA showed significant differences between the clusters on all variables. A Bonferroni post-hoc analysis was conducted to determine pairwise significant differences. No significant differences were found between cluster 3 and cluster 4 regarding Risk Tolerance. All other pairwise differences were significant (see Table 2). Based on these results, we distinguished four meaningful student profiles.

The first part of the second research question asked *how students in the different profiles differ in their perceived Boundary-crossing Behaviour*.

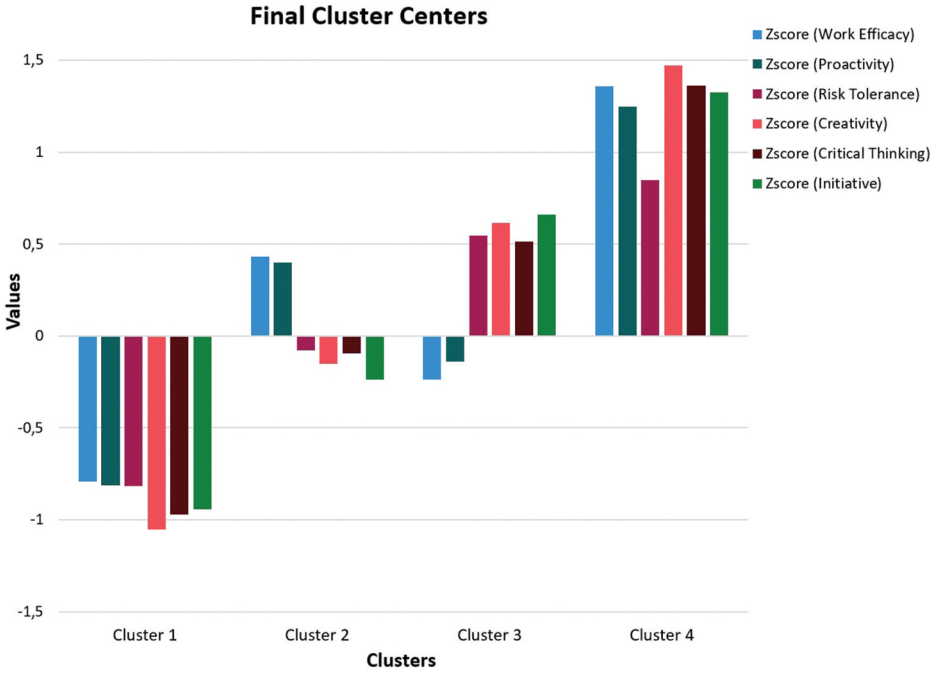

Figure 2. Bar chart representing the final clusters.

Table 2. Z scores for the attribute scales for the four extracted clusters, together with F values.

Scale	Cluster 1 n = 73 (27.7%)	Cluster 2 n = 85 (32.2%)	Cluster 3 n = 77 (29.2%)	Cluster 4 n = 29 (11.0%)	*(df) F*
Work Efficacy	−0.79150	0.43031	−0.23647	1.35899	(3) 71.99***
Proactivity	−0.81192	0.40010	−0.14138	1.24648	(3) 60.70***
Risk Tolerance	−0.81761	−0.07867	0.54356[a]	0.84545[a]	(3) 47.26***
Creativity	−1.05480	−0.15282	0.61411	1.47253	(3) 172.72***
Critical Thinking	−0.97054	−0.09437	0.51166	1.36111	(3) 103.92***
Initiative	−0.94194	−0.23907	0.65886	1.32243	(3) 122.00***

Superscripts indicate results of between-cluster pairwise comparisons across the row. All values differ significantly from each other at the $p < 0.05$ level, except the values marked by the same superscript. Bonferroni adjustment was applied.
***p < 0.001.

Therefore, another one-way ANOVA was performed with the behavioural scale, which showed significant differences between the clusters. The Bonferroni post-hoc analysis showed pairwise significant differences for Boundary-crossing Behaviour between all clusters, except between cluster 2 and 3 (see Table 3).

The second part of the second research question asked *how the student profiles differ regarding Relevant Work Experience*. The results of the Chi-square tests for Relevant Work Experience showed significant differences between clusters 1 and 3, and between clusters 2 and 3 (see Table 4).

Table 3. Means and standard deviations for attributes and behavioural scale, per cluster.

	Cluster 1 n = 73 (27.7%)		Cluster 2 n = 85 (32.2%)		Cluster 3 n = 77 (29.2%)		Cluster 4 n = 29 (11.0%)	
Scale	M	SD	M	SD	M	SD	M	*SD*
Attribute scales								
Work Efficacy	3.27	0.396	3.89	0.328	3.55	0.416	4.37	0.393
Proactivity	3.25	0.375	3.80	0.351	3.56	0.358	4.19	0.304
Risk Tolerance	2.95	0.615	3.45	0.551	3.87[a]	0.511	4.07[a]	0.402
Creativity	3.15	0.255	3.56	0.236	3.90	0.208	4.28	0.419
Critical Thinking	3.26	0.335	3.70	0.364	4.00	0.289	4.43	0.399
Initiative	3.06	0.365	3.43	0.288	3.90	0.320	4.25	0.458
Behavioural scale								
Boundary-crossing Behaviour	2.56	0.359	2.84[a]	0.325	2.86[a]	0.331	3.06	0.390

Superscripts indicate results of between-cluster pairwise comparisons across the row. All values differ significantly from each other at the $p < 0.05$ level, except the values marked by the same superscript. Bonferroni adjustment was applied.

Table 4. Chi-square table for relevant work experience per cluster.

		Cluster 1 n = 73 (27.7%)	Cluster 2 n = 85 (32.2%)	Cluster 3 n = 77 (29.2%)	Cluster 4 n = 29 (11.0%)	Total
Relevant Work	No	59[a]	66[a]	44[b]	20[a, b]	189
Experience		(80.8%)	(77.6%)	(57.1%)	(69.0%)	(71.6%)
$\chi^2 = 12.593$, $df = 3$,	Yes	14[a]	19[a]	33[b]	9[a, b]	75
$P = 0.006$		(19.2%)	(22.4%)	(42.9%)	(31.0%)	(28.4%)
	Total	73	85	77	29	264
		100.0%	100.0%	100.0%	100.0%	100.0%

Superscripts indicate results of between-cluster pairwise comparisons across the row. All values differ significantly from each other at the $p < 0.05$ level, except the values marked by the same superscript. Bonferroni adjustment was applied.

Student profiles

The results of our cluster analysis revealed four different profiles based on students' attributes (Creativity, Critical Thinking, Initiative, Proactivity, Risk Tolerance, and Work Efficacy) regarding dealing with problems with wicked tendencies in multi-stakeholder settings. Furthermore, we found meaningful relations with their Boundary-crossing Behaviour and Relevant Work Experience.

Profile 1 is characterised by low scores on all six attributes, as well as on students' Boundary-crossing Behaviour, and has the lowest share of students with Relevant Work Experience. Profile 2 is characterised by above-average degrees of Work Efficacy and Proactivity, but slightly below-average scores on the other attributes. Conversely, profile 3 has slightly below-average scores on Work Efficacy and Proactivity, but above-average degrees of the other four attributes. Profile 3 holds the largest share of students with Relevant Work Experience (43%), which is significantly higher than in profiles 1 (19%) and 2 (22%). Profiles 2 and 3 do not differ regarding their (slightly above-average) cluster scores on Boundary-crossing Behaviour, which are significantly higher than the cluster score of the students in profile 1, and significantly lower than the cluster score of the students in

profile 4. Profile 4 is characterised by high scores on all six attributes, though the cluster score on Risk Tolerance is not significantly higher than in profile 3. The cluster score on Boundary-crossing Behaviour is also high. The share of students with Relevant Work Experience in profile 4 is not significantly different than in profile 3 (31%, versus 43% in profile 3). For a full overview of the *Z*-scores for the overall scales and their items for the four profiles, see Appendix A (Attributes) and Appendix B (Boundary-crossing Behaviour).

Conclusions and discussion

Student profiles

The results of our cluster analysis revealed four profiles based on students' attributes that comprise the competence for dealing with wickedness. We found that low attribute levels (Profile 1) were associated with low perceived Boundary-crossing Behaviour, and high attribute levels (Profile 4) with high perceived Boundary-crossing Behaviour. These findings substantiate the notion that personal attributes play a significant role in how students engage with new (boundary-crossing) learning opportunities (Deakin Crick and Goldspink 2014) when facing problems with wicked tendencies. Furthermore, the fact that profiles 2 and 3, having distinct attribute patterns and significant differences in Relevant Work Experience, exhibited a similar cluster score on Boundary-Crossing Behaviour, implies that the reasons for the slightly above-average degree of perceived Boundary-crossing Behaviour may be different for these groups.

Several issues warrant careful scrutiny. First, the patterns for the Work Efficacy and Proactivity scores in profiles 2 and 3 deviate from the patterns for the other scales. The Work Efficacy scale is based on the conjecture that people who feel competent at doing their work and tasks tend more to pick up new things, or do things differently (Butter and van Beest 2015, 2017). This openness to new experiences is a valuable resource for learning (Deakin Crick and Goldspink 2014). The Proactivity scale measures the tendency to identify opportunities and ways to improve and to develop oneself, by learning with and from others, such as by seeking feedback. Both tendencies can be associated with a learning orientation (Arenas, Tabernero, and Briones 2006; Deakin Crick and Goldspink 2014; Murphy and Alexander 2000). A learning (goal) orientation pertains to a desire to developing competence through effortful learning (Murphy and Alexander 2000) and understanding or mastering new aspects (Hero, Lindfors, and Taatila 2017). Hence, we conjecture that students in profile 2 and 4 might have a stronger learning orientation than the students in profile 1 and 3, who scored low on both attributes.

Second, the Creativity, Critical Thinking, and Initiative scores, all showing a pattern of increase from profile 1 to profile 4, measure elements associated with students' tendency to actively contribute to the (joint) purpose and tasks related to the problem-solving process. Examples are: 'present novel ideas', 'generate original solutions', 'show inventiveness in using resources' (Creativity); 'challenge the status quo', 'develop … new ways of problem solving' (Critical Thinking); 'convince people to support an innovative idea', and 'foster improvements' (Initiative). These tendencies point to a problem-solving orientation. We thus conjecture that the students in profiles 3 and 4 have a higher problem-solving orientation than the students in profiles 1 and 2, who scored low on these attributes.

Third, Risk Tolerance shows a pattern of increase from profile 1 to profiles 3 and 4 (no significant difference between profiles 3 and 4). Relevant Work Experience shows a similar ascending pattern (significant differences between profiles 1 and 3, and between 2 and 3). Thus, to some extent, Risk Tolerance and Relevant Work Experience are related (Bhandari et al. 2021). These findings align with prior research. Karakowsky and Elangovan (2001) found that higher levels of individual Risk Tolerance can be associated with the confidence gained through repetitive exposure to feasible amounts of risk and uncertainty in Relevant Work Experience. Furthermore, Arenas, Tabernero, and Briones (2006) found that as people acquire new skills and become familiar with new contexts over time, the initial impact of the confrontation with wickedness and risks on their (work) performance diminishes. This then enables them to develop more positive orientations towards risk (and failure). In this study, we refer to this positive orientation towards risk as risk orientation. We conjecture that the students in profiles 3 and 4 have a higher risk orientation than the students in profile 1 and 2, who scored low(er) on Risk Tolerance and were less likely to have Relevant Work Experience.

Based on our findings and conjectures, we characterise the student profiles in terms of learning orientation (Work Efficacy, Proactivity), problem-solving orientation (Creativity, Critical Thinking, Initiative), risk orientation (Risk Tolerance, assumed prior exposure to wickedness through Relevant Work Experience), and perceived Boundary-Crossing Behaviour. See Table 5.

The attributes the inexperienced students in Profile 1 possess point neither to a learning orientation, nor to a problem-solving orientation. Having had little

Table 5. Characterisation of the student profiles based on students' orientations and boundary-crossing behaviour.

	Profile 1	Profile 2	Profile 3	Profile 4
Learning Orientation	Low	Above average/High	Slightly below average	High
Problem-Solving Orientation	Low	Slightly below average	Above average/High	High
Risk Orientation	Low	Below average	High	High
Boundary-Crossing Behaviour	Low	Slightly above average	Slightly above average	High

exposure to wickedness in prior work experiences, they are likely to be avoiders of risk and failure and are therefore not boundary crossers.

Students in Profile 2 possess the attributes that are important for learning, but not the attributes associated with a problem-solving orientation. As they are inexperienced, they also feel uncomfortable when taking risks and interacting with stakeholders at the boundary zone.

The students in Profile 3 possess attributes that point to a problem-solving orientation. Because of their work experience, they are not afraid to take risks. However, with a relatively low orientation to learning with and from others, the learning potential of the boundaries they experience remains partly unexploited.

Students in Profile 4 possess the attributes associated with a problem-solving orientation important for addressing wickedness, as well as the attributes that point to a learning orientation. They are not afraid of taking risks or experiencing failure and are good boundary crossers.

Possible implications of the student profiles for teacher strategies

To foster engagement and positive risk orientation and to prevent avoidance behaviour (Veltman, Van Keulen, and Voogt 2022), we conjecture that for students in profile 1 (and profile 2) it is important to ensure that initial experiences with uncertainty and risk-taking are conducted in a safe environment. This can be achieved by adopting an appreciative and empathetic approach to handling and responding to failure at the group level (Arenas, Tabernero, and Briones 2006). Moreover, optimising the potential for learning from those experiences, such as by formative and process-oriented approaches and by minimising the consequences of failure, can provide additional support. We propose that the students in profile 3 and profile 4, who have higher risk tolerance, can be exposed to higher levels of uncertainty.

Furthermore, a high degree of wickedness can be paralysing for students in profile 1 and profile 2, whose problem-solving orientation is low (profile 1) or slightly below average (profile 2). It could generate too much (destructive) tension and could lead to avoidance (Veltman, Van Keulen, and Voogt 2022). Conversely, it may be crucial for students in profile 3 and profile 4, with a high(er) problem-solving orientation, to be adequately challenged (Veltman, Van Keulen, and Voogt 2019). Therefore, we conjecture that offering flexibility and the integration of personal learning goals, whilst still pursuing the same learning outcomes in HPE, could prove beneficial in this context.

For the students in profiles 1 and profile 3, whose learning orientation is low (profile 1) or slightly below average (profile 3), it might be important to emphasise how and with whom the problems are addressed and to elicit what can be learned from their experiences during the problem-solving process (Veltman, Van Keulen, and Voogt 2019).

In general, we recommend that both teachers and students become more aware of students' attributes and orientations towards learning, problem-solving, and risk. Furthermore, we recommend encouraging students to deal constructively with variability in attributes, orientations, and prior experiences among their peers and others involved in the problem-solving process (Arenas, Tabernero, and Briones 2006), and to seek benefit from this diversity (Guile and Unwin 2020).

Critical reflections and recommendations for future work

The results of this study must be interpreted with caution. There are a few limitations to consider. First, whilst the intentional integration of the questionnaire within the students' authentic problem-solving endeavours strengthens the authenticity and relevance of our findings, the study captured a snapshot. In this sense our approach deviates from the proposed methodological implications of activity theory perspective, which imply longer research time frames, attention to the broad patterns of activities, and the use of various data collection techniques (Nardi 1996). However, our approach aligns with our research questions, emphasising the need for a nuanced examination of students' competences within the dynamic context of problems with wicked tendencies. Furthermore, the ecological validity of the study is enhanced by the fact that the educational setting, a first-year social work module at a university of applied sciences, has been studied in our preceding qualitative studies, thus doing justice to the proposed methodological implications by Nardi (1996). This continuity in the ecological setting across studies supports the generalisation of findings and contributes to the ecological validity of the research. Additionally, a fourth methodological implication of activity theory, as proposed by Nardi (1996), is the commitment to obtain an understanding from the users (i.e. the students') point of view. This is precisely what we have attempted with this study.

Second, recognising the limitations of self-assessment is vital. Students may not consistently offer accurate self-evaluations due to influences like social desirability and perception biases (Mulder 2014).

Third, boundary-crossing behaviour was measured with the boundary-crossing rubric (Gulikers and Oonk 2019), which was not originally designed as a research instrument. Contrary to our expectations, our results did not show patterns at the level of the four learning mechanisms (Akkerman and Bakker 2011). Moreover, we measured students' perceived boundary-crossing behaviour, rather than their actual behaviour. For future research, we suggest using additional qualitative methods, such as observations, to measure students' actual boundary-crossing behaviour more comprehensively in relation to these profiles.

Fourth, we conjecture that the students in our sample with different attribute profiles also have different orientational profiles (Arenas, Tabernero, and Briones 2006; Murphy and Alexander 2000), but did not measure this directly. Therefore, future research might expand upon the present study by including orientations towards learning, problem-solving, and risk as additional cluster variables and by exploring their relations with students' attributes, Relevant Work Experience, and perceived Boundary-Crossing Behaviour.

Fifth, although the students in our sample varied in age and work experience, they were all enrolled in the first year of their bachelor's programme. Including participants in senior years in future studies could help determine if the identified student profiles are effective to characterise a broader group in which more have had Relevant Work Experience or other prior exposure to manifestations of wickedness.

A sixth critical reflection concerns the nature and relevance of students' prior work experience. It is unknown how and to what extent students experienced wickedness and learnt to deal with it. Nor do we know how these experiences affected students' work efficacy and risk tolerance, and how the collective orientations towards risk in their work environments were influential. Orientations at the group level can either foster or adversely affect students' Work Efficacy (Arenas, Tabernero, and Briones 2006).

Our study provides insight into the attributional variability among students that affects how they perceive and navigate the complexity, uncertainty, and value divergence of problems with wicked tendencies that transcend disciplinary and organisational boundaries. These findings might help raise teachers' awareness of these attributes and orientations that underlie students' observable boundary-crossing behaviour. In addition, they might help teachers tailor their support and learning tasks to different groups of students to promote each student's development in the context of wickedness by fostering their positive orientations towards learning, problem-solving, and risk. For future research, we recommend testing and refining these conjectures for teacher strategies with qualitative approaches.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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References

Akkerman, S. F., and A. Bakker. 2011. "Boundary Crossing and Boundary Objects." *Review of Educational Research* 81 (2): 132–169. https://doi.org/10.3102/0034654311404435.

Akkerman, S. F., and T. Bruining. 2016. "Multilevel Boundary Crossing in a Professional Development School Partnership." *Journal of the Learning Sciences* 25 (2): 240–284. https://doi.org/10.1080/10508406.2016.1147448.

Amabile, T. M. 1996. *Creativity in Context: Update to the Social Psychology of Creativity*. Boulder, CO: Westview Press.

Arenas, A., C. Tabernero, and E. Briones. 2006. "Effects of Goal Orientation, Error Orientation and Self-Efficacy on Performance in an Uncertain Situation." *Social Behavior & Personality: An International Journal* 34 (5): 569–586. https://doi.org/10.2224/sbp.2006.34.5.569.

Ashford, S. J., and L. L. Cummings. 1985. "Proactive Feedback Seeking: The Instrumental Use of the Information Environment." *Journal of Occupational Psychology* 58 (1): 67–79. https://doi.org/10.1111/j.2044-8325.1985.tb00181.x.

Avvisati, F., G. Jacotin, and S. Vincent-Lancrin. 2013. "Educating Higher Education Students for Innovative Economies: What International Data Tells Us." *Tuning Journal for Higher Education* 1 (1): 223–240. https://doi.org/10.18543/tjhe-1(1)-2013pp223-240.

Bateman, T. S., and J. M. Crant. 1993. "The Proactive Component of Organizational Behavior: A Measure and Correlates." *Journal of Organizational Behavior* 14 (2): 103–118. https://doi.org/10.1002/job.4030140202.

Bhandari, S., M. R. Hallowell, W. Alruqi, and R. Salas. 2021. "Modeling the Relationship Between Personal Risk Tolerance, Work-Related Risk Tolerance, and Risk-Taking Behavior of Construction Workers." *Journal of Construction Engineering and Management* 147 (4). https://doi.org/10.1061/(ASCE)CO.1943-7862.0002021.

Butter, R., and W. van Beest. 2015. "Hoe herkent u innovators in uw organisatie" [How to recognize innovators in your organisation]?" *Md: Tijdschrift voor Talent en Managementontwikkeling* 2015 (4): 14–19.

Butter, R., and W. van Beest. 2017, June. "Psychometric Validation of a Tool for Innovation Competencies Development and Assessment Using a Mixed-Method Design." *Paper presented at EURAM*, Glasgow, Scotland.

Caliński, T., and J. Harabasz. 1974. "A Dendrite Method for Cluster Analysis." *Communications in Statistics - Theory and Methods* 3 (1): 1–27. https://doi.org/10.1080/03610927408827101.

Caratozzolo, P., A. Alvarez-Delgado, and S. Hosseini. 2020, April. "Metacognitive Awareness and Creative Thinking: The Capacity to Cope with Uncertainty in Engineering." *Paper presented at the IEEE Global Engineering Education Conference*, Al Porto, Portugal.

Chatenier, E. D., J. M. Verstegen, H. A. Biemans, M. Mulder, and O. F. Omta. 2010. "Identification of Competencies for Professionals in Open Innovation Teams." *R&D Management* 40 (3): 271–280. https://doi.org/10.1111/j.1467-9310.2010.00590.x.

Da Silva, N., and A. Davis. 2011. "Absorptive Capacity at the Individual Level: Linking Creativity to Innovation in Academia." *The Review of Higher Education* 34 (3): 355–379. https://doi.org/10.1353/rhe.2011.0007.

Deakin Crick, R., and C. Goldspink. 2014. "Learner Dispositions, Self-Theories and Student Engagement." *British Journal of Educational Studies* 62 (1): 19–35. https://doi.org/10.1080/00071005.2014.904038.

Engeström, Y.1987. *Learning by Expanding: An Activity-Theoretical Approach to Developmental Research*. Orienta-Konsultit.

Engeström, Y., R. Engeström, and M. Kärkkäinen. 1995. "Polycontextuality and Boundary Crossing in Expert Cognition: Learning and Problem Solving in Complex Work Activities." *Learning and Instruction* 5 (4): 319–336. https://doi.org/10.1016/0959-4752(95)00021-6.

Funke, J., A. Fischer, and D. V. Holt. 2018. "Competencies for Complexity: Problem Solving in the Twenty-First Century." In *Assessment and Teaching of 21st Century Skills: Research and Applications*, edited by E. Care, P. Griffin, and M. Wilson, 41–53. Cham: Springer. https://doi.org/10.1007/978-3-319-65368-6_3.

Gonczi, A. 2003. "Teaching and Learning of the Key Competencies." In *Contribution to the Second DeSeco Symposium*, edited by D.S. Rychen, L.H. Salganik, and M.E. McLaughlin, 119–131. Neuchatel, Switzerland: Swiss Federal Statistical Office.

Gore, P. A., Jr. 2000. "Cluster Analysis." In *Handbook of Applied Multivariate Statistics and Mathematical Modelling*, edited by H.E.A. Tinsley and S.D. Brown, 297–321. San Diego: Academic Press.

Grohs, J. R., G. R. Kirk, M. M. Soledad, and D. B. Knight. 2018. "Assessing Systems Thinking: A Tool to Measure Complex Reasoning Through Ill-Structured Problems." *Thinking Skills and Creativity* 28:110–130. https://doi.org/10.1016/j.tsc.2018.03.003.

Guile, D., and L. Unwin. 2020. "Expertise as a 'Capacity for Action': Reframing Vocational Knowledge from the Perspective of Work." *Journal of Vocational Education & Training* 74 (1): 31–49. https://doi.org/10.1080/13636820.2020.1858939.

Gulikers, J., and C. Oonk. 2016. ""Het waarderen van leren met partijen buiten de school" [Appreciating learning with partners outside the school]." *OnderwijsInnovatie* 3 (4): 17–26.

Gulikers, J., and C. Oonk. 2019. "Towards a Rubric for Stimulating and Evaluating Sustainable Learning." *Sustainability* 11 (4): 969. https://doi.org/10.3390/su11040969.

Hager, P. 2017. "The Integrated View on Competence." In *Competence-Based Vocational and Professional Education: Issues, Concerns and Prospects*, edited by M. Mulder, 203–228. Cham: Springer. https://doi.org/10.1007/978-3-319-41713-4_10.

Head, B. W. 2008. "Wicked Problems in Public Policy." *Public Policy* 3 (2): 101–118.

Head, B. W. 2019. "Forty Years of Wicked Problems Literature: Forging Closer Links to Policy Studies." *Policy and Society* 38 (2): 1–18. https://doi.org/10.1080/14494035.2018.1488797.

Head, B. W., and J. Alford. 2015. "Wicked Problems: Implications for Public Policy and Management." *Administration & Society* 47 (6): 711–739. https://doi.org/10.1177/0095399713481601.

Head, B. W., and W.-N. Xiang. 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.

Hero, L.-M., E. Lindfors, and V. Taatila. 2017. "Individual Innovation Competence: A Systematic Review and Future Research Agenda." *International Journal of Higher Education* 6 (5): 103–121. https://doi.org/10.5430/ijhe.v6n5p103.

Karakowsky, L., and A. Elangovan. 2001. "Risky Decision Making in Mixed-Gender Teams: Whose Risk Tolerance Matters?" *Small Group Research* 32 (1): 94–111. https://doi.org/10.1177/104649640103200105.

Keinänen, M., and R. Butter. 2018. "Applying a Self-Assessment Tool to Enhance Personalized Development of Students' Innovation Competences in the Context of University-Company Cooperation." *Journal of University Pedagogy* 2 (1): 18–28.

Keinänen, M. M., and L. Kairisto-Mertanen. 2019. "Researching Learning Environments and Students' Innovation Competences." *Education + Training* 61 (1): 17–30. https://doi.org/10.1108/ET-03-2018-0064.

Leys, C., M. Delacre, Y. L. Mora, D. Lakens, and C. Ley. 2019. "How to Classify, Detect, and Manage Univariate and Multivariate Outliers, with Emphasis on Pre-Registration." *International Review of Social Psychology* 32 (1): 1–10. https://doi.org/10.5334/irsp.289.

Little, R. J. 1988. "A Test of Missing Completely at Random for Multivariate Data with Missing Values." *Journal of the American Statistical Association* 83 (404): 1198–1202. https://doi.org/10.1080/01621459.1988.10478722.

Marin-Garcia, J. A., M.Á. Andreu-Andrés, L. Atares-Huerta, L. E. Aznar-Mas, A. Garcia-Carbonell, F. González-Ladrón-de-Guevara, B. Montero Fleta, M. J. Perez-Peñalver, and F. Watts. 2016. "Proposal of a Framework for Innovation Competencies Development and Assessment (FINCODA)." *WPOM-Working Papers on Operations Management* 7 (2): 119–126. https://doi.org/10.4995/wpom.v7i2.6472.

Milner, M., and T. A. Wolfer. 2021. "Using the Reflective Judgment Model to Understand and Appraise Effective Reasoning by Social Work Students." *Journal of Social Work Education* 59 (1): 78–90. https://doi.org/10.1080/10437797.2021.1970064.

Mulder, M. 2014. "Conceptions of Professional Competence." In *International Handbook of Research in Professional and Practice-Based Learning*, edited by S. Billett, C. Harteis, and H. Gruber, 107–137. Dordrecht: Springer. https://doi.org/10.1007/978-94-017-8902-8_5.

Murphy, P. K., and P. A. Alexander. 2000. "A Motivated Exploration of Motivation Terminology." *Contemporary Educational Psychology* 25 (1): 3–53. https://doi.org/10.1006/ceps.1999.1019.

Nardi, B. A. 1996. "Studying Context: A Comparison of Activity Theory, Situated Action Models, and Distributed Cognition." In *Context and Consciousness: Activity Theory and Human-Computer Interaction*, edited by B.A. Nardi, 69–102. Cambridge, MA: MIT Press.

Neubert, J., T. Lans, M. Mustafic, S. Greiff, and P. Ederer. 2017. "Complex Problem-Solving in a Changing World: Bridging Domain-Specific and Transversal Competence Demands in Vocational Education." In *Competence-Based Vocational and Professional Education: Issues, Concerns and Prospects*, edited by M. Mulder, 953–969. Cham: Springer. https://doi.org/10.1007/978-3-319-41713-4_44.

Newman, J., and B. W. Head. 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. 2007. "From 'Pure' to 'Hybrid' Professionalism: Present-Day Professionalism in Ambiguous Public Domains." *Administration & Society* 39 (6): 761–785. https://doi.org/10.1177/0095399707304434.

Noordegraaf, M., S. Douglas, K. Geuijen, and M. van der Steen. 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.

Odello, T., E. Hill, and E. Gómez. 2008. "Challenge Course Effectiveness: The Impact on Leadership Efficacy and Work Efficacy Among College Students." *Journal of Unconventional Parks, Tourism and Recreation Research* 1 (1): 18–22.

Penttilä, T., and L. Kairisto-Mertanen. 2013. "Developing Innovation Competences Through Boundary Crossing in a Social Learning Environment. In Lehto, A., and Penttilä, T. (Eds.), *Pedagogical Views on Innovation Competencies and Entrepreneurship. Innovation Pedagogy and Other Approaches*, 34–44. Turku: Turku University of Applied Science.

Pihie, Z. A. L., and A. S. A. Sani. 2009. "Exploring the Entrepreneurial Mindset of Students: Implications for Improvement of Entrepreneurial Learning at University." *The Journal of International Social Research* 2 (8): 340–345.

Rittel, H., and M. M. Webber. 1973. "Dilemmas in a General Theory of Planning." *Policy sciences* 4 (2): 155–169. https://doi.org/10.1007/BF01405730.

Rosso, B. D. 2014. "Creativity and Constraints: Exploring the Role of Constraints in the Creative Processes of Research and Development Teams." *Organization Studies* 35 (4): 551–585. https://doi.org/10.1177/0170840613517600.

Roth, W.-M., and Y.-J. Lee. 2007. "'Vygotsky's Neglected legacy': Cultural-Historical Activity Theory." *Review of Educational Research* 77 (2): 186–232 https://doi.org/10.3102/0034654306298273.

Rychen, D. S. E., and L. J. E. Salganik. 2001. *Defining and Selecting Key Competencies*. Kirkland, WA: Hogrefe & Huber Publishers.

Santandreu-Mascarell, C., D. Garzon, and H. Knorr. 2013. "Entrepreneurial and Innovative Competences, are They the Same?" *Management Decision* 51 (5): 1084–1095. https://doi.org/10.1108/MD-11-2012-0792.

Şeremet, M., M. Haigh, and E. Cihangir. 2021. "Fostering Constructive Thinking About the 'Wicked Problems' of Team-Work and Decision-Making in Tourism and Geography." *Journal of Geography in Higher Education* 45 (4): 517–537. https://doi.org/10.1080/03098265.2020.1869924.

Smith, J., N. Shaw, and J. Tredinnick. 2015. "Practice-Based Learning in Community Contexts: A Collaborative Exploration of Pedagogical Principles." In *Practice-Based Learning in Higher Education*, edited by S. Kennedy, S. Billett, S. Gherardi, and L. Grealish, 141–157. Cham: Springer.

Suchman, L. 1994. "Working Relations of Technology Production and Use." *Computer Supported Cooperative Work* 2:21–39. https://doi.org/10.1007/BF00749282

Ten Dam, G., and M. Volman. 2004. "Critical Thinking as a Citizenship Competence: Teaching Strategies." *Learning and Instruction* 14 (4): 359–379. https://doi.org/10.1016/j.learninstruc.2004.01.005.

Termeer, C. J. A. M., A. Dewulf, G. Breeman, and S. J. Stiller. 2015. "Governance Capabilities for Dealing Wisely with Wicked Problems." *Administration & Society* 47 (6): 680–710. https://doi.org/10.1177/0095399712469195.

Tornau, K., and M. Frese. 2013. "Construct Clean-Up in Proactivity Research: A Meta-Analysis on the Nomological Net of Work-Related Proactivity Concepts and Their Incremental Validities." *Applied Psychology* 62 (1): 44–96. https://doi.org/10.1111/j.1464-0597.2012.00514.x.

Veltman, M. E., J. Van Keulen, and J. M. Voogt. 2019. "Design Principles for Addressing Wicked Problems Through Boundary Crossing in Higher Professional Education." *Journal of Education & Work* 32 (2): 135–155. https://doi.org/10.1080/13639080.2019.1610165.

Veltman, M. E., J. Van Keulen, and J. M. Voogt. 2021. "Using Problems with Wicked Tendencies as Vehicles for Learning in Higher Professional Education: Towards Coherent Curriculum Design." *The Curriculum Journal* 32 (3): 559–583. https://doi.org/10.1002/curj.100.

Veltman, M. E., J. Van Keulen, and J. M. Voogt. 2022. "Teacher Strategies That Foster students' Boundary-Crossing Expertise When Addressing Problems with Wicked Tendencies." *Journal of Vocational Education & Training* 1–28. https://doi.org/10.1080/13636820.2022.2138509.

Wenger, E. 2000. "Communities of Practice and Social Learning Systems." *Organization* 7 (2): 225–246. https://doi.org/10.1177/135050840072002.

Young, W., G. Weckman, and W. Holland. 2011. "A Survey of Methodologies for the Treatment of Missing Values within Datasets: Limitations and Benefits." *Theoretical Issues in Ergonomics Science* 12 (1): 15–43. https://doi.org/10.1080/14639220903470205.

Appendices

Appendix A. Z Scores for the Constitutive Attribute Scales and Respective Items for the Four Extracted Clusters, Together with F Values (N = 264)

Scale	Cluster 1 $n = 73$(27.7%)	Cluster 2 $n = 85$(32.2%)	Cluster 3 $n = 77$(29.2%)	Cluster 4 $n = 29$ (11.0%)	*(df) F*
Work Efficacy	−0.79150	0.43031	−0.23647	1.35899	(3) 71.99***
WE1: Someone who feels freedom to pick up new things as part of their job responsibilities	−0.59535055	0.19628145[a]	−0.029424909[a]	1.001461548	(3) 24.68***
WE2: Someone who clearly knows what is expected from themselves	−0.554132776[a]	0.363353117	−0.22777804[a]	0.934675405	(3) 27.28***
WE3: Someone who thinks they are good at their work	−0.664158495	0.362445722	−0.123712839	0.937985255	(3) 31.47***
WE4: Someone who can do their core tasks in a routine manner	−0.526690638[a]	0.335806172	−0.293350457[a]	1.120444038	(3) 33.22***
Proactivity	−0.81192	0.40010	−0.14138	1.24648	(3) 60.70***
P1: Someone who can improve themselves	−0.510184885[a]	0.349030316	−0.266065909[a]	0.967689475	(3) 26.712***
P2: Someone who is looking for ways to improve work processes	−0.541376246	0.274015515	−0.133726274	0.914692079	(3) 22.089***
P3: Someone who is trying to improve the products or services which they work with/on	−0.543790045	0.234225817[ab]	0.007451975[a]	0.662540577[b]	(3) 15.082***
P4: Someone who regularly asks others for feedback on their own performance	−0.385804714[a]	0.22347554	−0.171995303[a]	0.772826261	(3) 13.177***
P5: Someone who regularly asks others for feedback on what they are involved in	−0.48942376	0.192486948[ab]	−0.015900282[a]	0.710029851[b]	(3) 13.425***
P6: Someone who asks for the opinion of others when they invent something new	−0.526610726[a]	0.39520631[b]	−0.180923454[a]	0.647625952[b]	(3) 19.449***
P7: Someone who is aware of the developments in their discipline allowing themselves to identify new opportunities	−0.606889441	0.132139679[a]	0.103849846[a]	0.864642012	(3) 20.789***
P8: Someone who checks if news that relates to their discipline or work field, is interesting for their work	−0.559469873	0.272285598[a]	−0.079985708[a]	0.822618083	(3) 19.978***
Risk Tolerance	−0.81761	−0.07867	0.54356[a]	0.84545[a]	(3) 47.26***
RT1: Someone who is willing to take risks in their work	−0.635329544	−0.140820898	0.432958662[a]	0.86244883[a]	(3) 29.719***
RT2: Someone who likes to take a challenge, even if it's a risk for the company/organisation	−0.700857175	−0.046300972	0.495781184[a]	0.583551902[a]	(3) 28.359***
RT3: Someone who takes risks in order to be innovative	−0.765969698	−0.019708162	0.465882296[a]	0.7488981[a]	(3) 35.119***
Creativity	−1.05480	−0.15282	0.61411	1.47253	(3) 172.72***
C1: Think differently and adopt different perspectives	−0.640487717	−0.113407701	0.402823271[a]	0.87509883[a]	(3) 28.884***
C2: Use intuition and own knowledge to start actions	−0.663530196	−0.082492665	0.459627784[a]	0.6916635 [a]	(3) 27.220***
C3: Find new ways to implement ideas	−0.607205653	−0.183446414	0.452793826[a]	0.863925285[a]	(3) 29.749***

(*Continued*)

Appendix A. (Continued).

Scale	Cluster 1 $n = 73$(27.7%)	Cluster 2 $n = 85$(32.2%)	Cluster 3 $n = 77$(29.2%)	Cluster 4 $n = 29$ (11.0%)	*(df) F*
C4: Generate original solutions for problems or to opportunities	−0.804673952	−0.126021634	0.59125098[a]	0.825059033[a]	(3) 49.231***
C5: Make suggestions to improve current process products or services	−0.674238714	−0.105682325	0.397186336	0.952381926	(3) 33.038***
C6: Present novel ideas	−0.668924953	−0.07095082	0.314297779	1.057290079	(3) 33.372***
C7: Show inventiveness in using resources	−0.610056611	−0.117171937	0.260633416	1.187068077	(3) 34.208***
C8: Search for new working methods, techniques, or instruments	−0.657748026	−0.109637969	0.396206169	0.925067526	(3) 31.133***
C9: Refine ideas into a useful form	−0.672509617	0.048328658[a]	0.221270556[a]	0.963704595	(3) 27.825***
Critical Thinking	−0.97054	−0.09437	0.51166	1.36111	(3) 103.92***
CT2: Develop and experiment with new ways of problem solving	−0.798493501	−0.178534941	0.59519502[a]	0.952947551[a]	(3) 55.673***
CT3: Challenge the status quo	−0.666901132	−0.099483853	0.416485574[a]	0.864500723[a]	(3) 30.425***
CT4: Face the task from different points of view	−0.673018154	0.056763056[a]	0.233927851[a]	0.906655897	(3) 26.391***
CT5: Forecast impact on users	−0.668782458	−0.078699362	0.295465953	1.129644374	(3) 35.816***
CT6: Ask 'Why?' and 'Why not?' and 'What if?' with a purpose	−0.656145851	−0.034211574[a]	0.278929057[a]	1.011348054	(3) 29.733***
Initiative	−0.94194	−0.23907	0.65886	1.32243	(3) 122.00***
I1: Foster improvements in work organisation	−0.543936869[a]	−0.214463788[a]	0.425617777[b]	0.867732569[b]	(3) 26.335***
I2: Take an acceptable level of risk to support new ideas	−0.728592968	−0.271158449	0.598912418[a]	1.038603403[a]	(3) 56.601***
I3: Go beyond expectations in the assignment, task, or job description without being asked	−0.772854964	−0.056806674	0.375152654	1.115869839	(3) 45.717***
I4: Convince people to support an innovative idea	−0.698386559	−0.109448149	0.476266515[a]	0.814234133[a]	(3) 33.498***
I5: Systematically introduce new ideas into work practices	−0.692050082	−0.226943368	0.536686861[a]	0.982239792[a]	(3) 44.705***
I6: Act quickly and energetically	−0.678235282	−0.158971877	0.460007981	0.95183347	(3) 36.738***

Superscripts indicate results of per-item between-cluster pairwise comparisons. All values differ significantly from each other at the $p < 0.05$ level, except the values marked by the same superscript. For example, value[a] is significantly different from value[b] and values with no superscript in the same row. Bonferroni adjustment was applied.

***$p < 0.001$.

Appendix B Z Scores of the Boundary-Crossing Behaviour Scale and Respective Items for the Four Extracted Clusters (N = 264)

Scale	Cluster 1 $n = 73$(27.7%)	Cluster 2 $n = 85$(32.2%)	Cluster 3 $n = 77$(29.2%)	Cluster 4 $n = 29$ (11.0%)
Boundary-Crossing Behaviour	−0.6167748	0.1207237[a]	0.1830129[a]	0.7127950
BC1: Knowing your own expertise and boundaries	−0.354902491	0.066648552[a]	0.179469055[a]	0.221504747[a]
BC2: Mapping stakeholders	−0.40478608[a]	−0.030539137[ab]	0.286290278[b]	0.348305483[b]
BC3: Approaching stakeholders	−0.273591843[b]	−0.03320515[b]	0.084153575[ab]	0.562579896[a]
BC4: Targeted collaboration	−0.231463456[a]	0.1648924[ab]	−0.097634821[ab]	0.35858136[b]
BC5: Putting yourself in someone else's shoes	−0.147725899[a]	0.004201009[a]	−0.010202451[a]	0.386637708[a]
BC6: Learning from the other	−0.258480534[a]	0.107008009[a]	0.045860575[a]	0.215245996[a]
BC7: Encouraging others to learn	−0.338818477[a]	0.02919784[ab]	0.195361643[b]	0.248589166[b]
BC8: Intention to develop a sustainable, new practice	−0.343133591[a]	0.13801993[b]	0.020589144[ab]	0.404541174[b]
BC9: Vision on new practices	−0.410775419	0.000201016[a]	0.222123004[a]	0.443656823[a]
BC10: Integration of interests and perspectives into a new practice	−0.474440992	0.13966563[a]	0.065036039[a]	0.61223582[a]
BC11: Incentives towards a follow-up	−0.449417593	0.102358671[a]	0.128009064[a]	0.491389633[a]

Superscripts indicate results of per-item between-cluster pairwise comparisons. All values differ significantly from each other at the $p < 0.05$ level, except the values marked by the same superscript. For example, value[a] is significantly different from value[b] and values with no superscript in the same row. Bonferroni adjustment was applied.