How to educate navigators in a complex world: making a case in higher professional education in The Netherlands

Paul van der Cingel

Abstract: *This article focuses on the increased relevance and urgency to pay explicit attention to complexity-informed perspectives on real-world issues in Dutch higher professional education. Moreover, it describes lessons learned from experiments with so-called Embedded Complexity Workshops. These workshops, comprised of activities like network visualization, yield promising results and can serve as a starting point for further development.*

Keywords: professional education; network visualization; connectivity; systemic awareness; ambiguity; dynamism

Introduction

Governments and other future employers of today's students, experience an increasing relevance and urgency to call on educational institutes to prepare students to deal with complex issues. In this article, the call to action is addressed by discussing the utility and use of so-called plug-in workshops in Dutch higher professional education. The workshops aimed at offering students alternative and complexity-informed perspectives on complex problems which they were already studying. In this article, we call this type of education Embedded Complexity Workshops, ECW's. In the first section, we outline our working definition of the concept of complexity. The second section provides some background information about tertiary, or higher, education in the Netherlands. In the third section, we will argue why it is necessary to develop ECW's. Section four covers the design of learning objectives that pave the way for developing and testing the plug-in workshops. The workshops themselves are described in section five. Section six draws conclusions and poses some questions for future experiments.

A working definition of complexity

Due to the multidisciplinary nature of complexity science, scientists, professionals and policymakers still lack a consensus definition of the concept of complexity (Heydari & Wade, 2014). In this article, our working definition of complexity contains three aspects: connectivity, ambiguity and dynamism.

Paul van der Cingel, Windesheim University of Applied Sciences, The Netherlands, E-mail: p.van.der.cingel@windesheim.nl

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The first aspect is connectivity, by which we mean that in a complex issue, various agents and factors are in some way related, linked, and interdependent. Taking a systemic perspective, one could say that this aspect of complexity is all about becoming aware that getting to know the whole requires knowledge of the system's components as well as their interrelationships.

The second aspect is ambiguity, by which we mean that relations between agents and factors can be multi-dimensional. For example, the relation between two agents can be financial, legal, organizational or social, effectively introducing potential tensions in relationships.

The third aspect is dynamism, by which we mean that in a complex system of interacting and adapting agents, change is certain to occur. For example, two agents may switch from a competitive to a collaborative relationship, adpating to the context of a changing situation. However, this does not mean that the system as a whole is in total flux. Rather, it is the dynamics of alternating between stability and change that constitutes complexity (Gerrits, 2012).

We label real-world systems, networks, problems, challenges and developments as "complex" if they match these three aspects. The relationship between two human beings would fit the bill, providing us with the example of complexity that is arguably the easiest to grasp.

In this article, we will encounter real-world issues that show considerably more complexity, because of a larger number of interrelated agents and factors.

The context of higher professional education in The Netherlands

Tertiary, or higher, education in The Netherlands is characterized by two distinct paths. The first path offers scientific research-oriented education, embedded in the common structure of bachelor and master programs. Currently, about 260,000 students take this path at some 20 universities.

The second path offers higher professional education, embedded in a four-year bachelor program. Currently, over 440,000 students follow this track at 37 Universities of Applied Sciences. Unlike other contributions to this special issue, this article focuses on education for students who still lack working experience in the relevant professional context.

Table 1 hightlights some of the differences:

Table 1

Selected differences between professional and research-oriented education in The Netherlands Adapted from: http://www.rug.nl/feb/education/premaster/hbo

Professional education at Universities of Applied Sciences	*Research-oriented education at Universities*
Higher vocational education emphasizes training for a specific profession.	The emphasis is on learning to look analytically and critically at the way a certain field can be approached.
The training is directed towards the acquisition of competences.	You learn to present convincing oral and written arguments and to draw conclusions from them.
Professions usually clear in advance: After you graduate, you will usually end up in a white-collar job.	Professions less clear in advance: Personnel ads often ask for an "academic level of thinking" rather than for specific knowledge.
More supervision: The contacts with students are often more intensive. There are usually more contact hours, including compulsory ones, such as lectures and work groups.	Less supervision: Own initiative, self-discipline, independence.

As can be glanced from table 1, setting up an academic course, e.g. "Introduction to Complexity Sciences", will not work in professional education. Here, ECW's should be developed bearing in mind that one single priority: the *purposeful application* of scientific insights within contexts of a *specific professional* field. Moreover, setting up a course which requires students to master literature (mostly in English) through self-study, will not work either. Here, ECW's should be developed in a framework of lectures and supervised work groups, in Dutch (or any other local language, depending on where this is taught).

Windesheim University of Applied Sciences has been ranked as one of the Dutch top institutes since a number of years (Windesheim, September 27, 2017). With a student population of over 25,000 and a staff of 2,000, it hosts 50 Bachelor programs. These Bachelor programs are preparing students for a great variety of professions. Table 2 lists examples of typical four-year Bachelor programs from various domains at Windesheim University.

Table 2

Examples of Bachelor programs at Windesheim University

Domain	*Examples of Bachelor programs and professional fields*
Technology	Engineering, Industrial Design, IT
Media	Journalism
Health	Applied Gerontology, Speech therapy
Business	Financial Services Management, Business & Information Management
Social Work	Socio-pedagogical care, Child Care Management
Education	Teaching in primary and secondary education, subjects ranging from Sports to Theology
Multidisciplinary	Global Project and Change Management
Honours Programs	

Windesheim University of Applied Sciences provided us with resources to develop and test new ways to implement ECW's.

Why? Making a case for ECW's in Dutch higher professional education

In this section, we will argue why there is a need for new ECW's in Dutch higher professional education. In order to make a credible case, we will examine two questions:

[1] How can we pinpoint the complexity that students in higher professional education will encounter?
[2] What are the deficiences in the regular curricula in teaching students how to deal with this complexity?

The question of pinpointing complexity

Just a few years ago, complexity-informed perspectives were almost exclusively offered in academic, research-oriented curricula. Within the context of professional education, complexity was no more than a buzz word, fashionably placed in forewords and introductions, but rarely taken seriously and recognised as having implications. For example, in 2014, an advisory committee wrote a report on the future of Business Programs in Dutch higher professional education. The report was commissioned by the **Netherlands Association of Universities of Applied Sciences (**Verkenningscommissie hoger economisch onderwijs (2014). The word "complex" was mentioned 20 times in the report, a stunning 9 of which stood in the foreword. A quote from the foreword read (translated from Dutch)

> "First and foremost, reflection on higher economic professional education means: teaching students that they have to accept that complexity and uncertainty are fundamental to our society…"
> (Verkenningscommissie hoger economisch onderwijs 2014, p.3)

The report did not live up to the expectations of the foreword's words. In the rest of the report, no advice was given as to how exactly students had to be taught the acceptance of complexity and uncertainty. This is typical for the "buzz word era", but indications are that this era is rapidly drawing to an end for reasons of relevance and urgency.

There are ample indications that complexity in society is increasing (Heydari & Wade 2014; Gosselin & Tindemans 2016; Coronges, Barabási & Vespignani 2016). Looking back to the aspects of our working definition of complexity, we can see that connectivity, ambiguity and dynamism are applicable to a growing range of real-world systems, problems, challenges and developments. This trend has been strengthening for a number of years, helped by a combination of rapid advances in internet technology and globalization. The expansion of the Internet of Things, and the anticipated rise of the Internet of Everything provides just one example of fast growing connectivity dynamism. The World Economic Forum's Global Agenda Council on Complex Systems (2013) recalls the metaphore of a web to describe connectivity in wicked problems like global climate change:

> "Many of the grand challenges that confront humanity often seem to entail impenetrable webs of cause and effect." (World Economic Forum's Global Agenda Council on Complex Systems 2013, p.2)

It is definitely not only on a global scale that complexity is on the rise. On the contrary, complexity is also increasing on the national, regional and local level. Tabel 3 provides an example from the author's professional deskresearch.

Table 3

An example of a real-world complex development in The Netherlands

Aspect of complexity working definition	*Example*
Connectivity	As of January 2015, some 390 local governments became responsible for the provision of healthcare services for their citizens. They had to close deals with suppliers from a group of 6,000 healthcare organizations. The deals could be one-year contracts or longer term commitments. Healthcare services were categorized into 120,000 different productcodes. The actual provision of healthcare was often organized into new, multidisciplinary teams, with teams typically covering parts of the cities or communities.
Ambiguity	Connections within this new 'ecosystem' were multi-dimensional. Governments and organizations could be linked legally and financially, while local healthcare teams operated as self-organizing networks of multidisciplinary professionals, personally linked through trust to citizens.
Dynamism	Connections could change over time, e.g. as one-year contracts came to an end or had to be renegotiated. This change in context caused some local governments to adapt their behaviour towards healthcare organizations, and incorporate new terms in contracts. This, in turn, triggered new actions in the healthcare sector, with some trying to respond to the new terms, and some leaving the arena.

Second, there is what we could call the argument of urgency. Organizations, businesses, institutes and governments are experiencing difficulties in coping with the consequences of growing complexity. For example, the 2010 IBM Global Chief Executive Officers Study revealed a gap between the level of complexity anticipated by CEOs versus their perceived ability to deal with complexity successfully (IBM 2010). As the study noted

> "Our interviews revealed that CEOs are now confronted with a "complexity gap" that poses a bigger challenge than any factor we've measured in eight years of CEO research." (IBM 2010, p.19)

A possible explanation is, that businesses, governments and other organizations are still mainly hierarchically structured into stable and discrete departments and silos. Thus, they lack the ability to mirror the complexity of their environment. Metaphorically speaking, one could say that they fail to comply with Ashby's law of requisite variety (Boisot & McKelvey 2011).

One indication that complexity is getting more 'hurtful', is the need to attend to evermore unintended consequences of planned projects, policies or strategies. In our example of table 3, one unintended consequence was the emergence of local governments becoming overly cautious, thus creating budget surpluses instead of using the full budget for healthcare.

It seems clear, then, that complexity has transcended the "buzz word era" and has reached the priority lists for attention. For instance in 2016, the World Economic Forum asked: What are the 21st-century skills every student needs? Respondents in its Future of Jobs Survey put complex problem solving skills on pole position (World Economic Forum 2016, pp.21-22).

The question of deficiences in regular curricula

The relevance and urgency to better cope with complexity that is felt in public organizations and businesses, feeds back to higher professional education. Looking back at table 1 this should not come as a surprise, as it states that "[...] higher vocational education emphasizes training for a specific profession". Therefore, all programs at Universities of Applied Sciences should be based on a consensus profile of the profession at hand: the body of knowledge and skills required for the specific profession. Input from organizations, businesses and governments from the professional field is considered important, because they are the future employers of the students.

Despite this obvious need to carefully monitor changing needs of the students' future employers, educational institutes find themselves struggling to integrate the changing needs into their curricula. The aforementioned advisory report commissioned by the Netherlands Association of Universities of Applied Sciences, is a typical case in point (Verkenningscommissie hoger economisch onderwijs 2014). It all boils down to the question exactly what needs to be changed in the existing curricula, and what can remain unchanged because it is still functioning satisfactorily.

Fred Janssen, in his recent inaugural lecture as professor of Science Education at Leiden University, stresses education's deep-rooted focus on teaching students how to solve "carefully structured puzzles" as opposed to teaching how to navigate in unstructured complex situations, which he calls "swamps" (Janssen 2017). His Chair will explicitly focus on scientific research which aims to bridge the gap.

The struggle is certainly not confined to higher education. In April 2017, the Inspectorate of Education, part of the Dutch Ministry of Education, Culture and Science, states in its yearly review of primary and secondary education: ", Dutch pupils find that their teachers stimulate them to tackle complex problems, less than in other countries" (Inspectie van het Onderwijs 2017, p.42).

The main conclusion of this section is, that future employers are explicitly and persistently calling on educational institutes to enhance complex problem solving skills with their pupils and students. In the next section we venture our approach on how to do just that.

From why to what: learning objectives

The experiments at Windesheim University of Applied Sciences aimed to enhance students' ability to deal with complex issues. Note how we consciously broadened the scope from *problems* to the wider concept of *issues*: problems, challenges, systems, networks and societal developments. Note also, that we stepped away from the perspective of problem *solving*, because we didn't want to go back to Janssens' frame of carefully constructed puzzles. Students are confronted with real-world complex issues, and they have to learn to deal with them, which differs from actually being able to solve them.

We started out by trying to construct learning objectives that captured the essence of student skills needed to deal with complexity. We let the following design principles guide us:

- Learning objectives should cover at least one (and, ideally all) of the three aspects of our working definition of complexity, as laid out in the first section: connectivity, ambiguity and dynamism.

- Learning objectives should mirror the priority of professional education, as laid out in the second section: the purposeful application of scientific insights within contexts of a specific professional field.

Given these design principles, we decided to develop workshops that were consciously embedded within an existing setting, as opposed to creating something new. In practice, this meant that our new eductional tools had to be "plugged in" as parts of programs where students were already studying real-world complex issues. This ensured that we were going to be working in the right setting: applying insights within a specific professional field. Ultimately, we started working with three learning objectives, which we labelled Insight, Research and Dialogue.

Insight

The first learning objective was to create systemic awareness and strengthen students' synthesizing skills, in order to deepen their insight into the complex issues at hand. Our assumption was, that much of the curricula that we were plugged into, focussed on "carefully constructed puzzles", teaching students to use their analytic skills to deconstruct the issue into discrete, disconnected components. Thus, in this traditional approach to problem solving we expected students to forget paying attention to the interconnectedness of agents in the issue. Our main objective instead was to get students to focus on *connectivity*. Furthermore, we wanted to nudge them into thinking about the multi-dimensionality of connections and possible tensions that might arise from the existence of various types of relationships (*ambiguity*).

Research

The second learning objective was to enhance the effectiveness of students' research into the complex issue, by making use of the insights into *connectivity* from the first learning objective. Here, we assumed that when we were being plugged into the curriculum, students had spent time collecting information about the complex issue at hand. We expected many students to be in some kind of struggle with information overload from a fragmented body of literature, data, etc. Our objective here was to let students review the system of their complex issue and assess which of the agents, factors and connections could be underpinned by the information gathered. We called this the known knowns. As students probably weren't able to underpin everything (yet), we consequently expected known unknowns to emerge.

Dialogue

The third learning objective was to foster dialogue within student teams, or between students and real-world stakeholders. Here, the idea was to let students share their perspective on the *connectivity*, *ambiguity* and *dynamism* of the complex issue at hand. We expected this dialogue not only to yield new insights, but also to create a movement to a shared vision on the complex issue.

Having set these objectives, we reached out to lecturers in the current programs at Windesheim University. In a variety of departments across the university, we found teachers who were willing to open up their courses for an experimental plug-in workshop.

From what to how: experimental workshops

By choosing a workshop setting, we created a learning environment of supervised working groups. As noted in the second section, that fitted optimally in the context of higher professional education. As noted in fourth section, by choosing a plug-in setting, we were certain that students were already working on complex issues from within their professional field. Table 4 offers an overview of the ECW's we conducted at Windesheim University.

Tabel 4

Experimental ECW's at Windesheim University

Domain	*Bachelor Program*	*Workshop aspects*	*Frequency*	*(example of) Complex issue in specific professional context*
Media	Journalism	3rd-year students; one-session workshop	Done twice (April 2016 and september 2016)	Create a story about house construction, land transactions and local government policy in a specific city or region, using the concept of Constructive Journalism
Health	Applied Gerontology	2nd-year students; two-session workshop	Done once (Jan 2017)	Development of new products in co-creation with elderly in a specific city district, using the Good Lives Model
Business	Business & Information Management	3rd-year students; one-session workshop	Done twice (November 2015 and November 2016)	Map out the customer journey of patients in short-stay clinics of a specific hospital, as a part of the design process of a new health care
Education	Teaching in primary and secondary education	1st-year students; two-session workshop	Done twice (both May 2017)	Make a documentary about the value of testing in primary and secundary education, specifically using the context of schools that hosted your internships
Multi-disciplinary Honours Programs	Global Project and Change Management	2nd-year students; three-session workshop	Done once (May 2017)	Map out existing youth health care initiatives in a specific city, in public, private commercial and private charitable contexts. Give advice on how to increase effectiveness of the city's program on combating obesity.

As can be seen in table 4, we were able to work in quite different programs at the university. It shows that the need for new ECW's clearly crosses departmental boundaries. A single workshop session took 2.5 to 4 hours. Depending on how much time we were given, we were able to conduct one-session workshops, but also multi-session workshops.

The main tool we used in the ECW's, was network visualization. Being a configuration of interconnected components, a network is particularly suited to represent the system of connected agents and factors of a specific complex issue. We used the term Network Literacy, originally coined by NetSciEd, the Network Science in Education Initiative to cover a set of activities in the workshops (Van der Cingel in press):

1. *Interactive presentation to create systemic awareness.* In the first part of the workshop we presented and discussed the concepts of complexity and very basic systems thinking. We showed that connectivity can be visualized by network diagrams.

2. *Class discussions to relate systemic awareness to the real-world issues that students are currently working on.* The goal of discussion was to let students discover that the issues they were currently studying, were actually complex. They were nudged into thinking about the question: how can we better deal with the connectivity, ambiguity and dynamism of the complex issue at hand? This was the moment to actually embed complexity-informed perspectives in the context of the current student activities.

3. *Making and discussing network diagrams.* We presented Network Literacy as a tool to better deal with the complexity in the issues that students were tackling. We asked them to hand-draw agents (e.g. stakeholders), factors (e.g. facilities, or contextual aspects like regulation) and their relationships in a network diagram. We explicitly encouraged students to think about multiple types of relationships. We then created a first moment for dialogue, as students shared their diagrams, in a round of peer review. Students could use the insights from this round to alter their diagram, or make an improved version. When they were working in teams, this was the moment that they were asked to merge the individual sketches into a "team diagram". The improved diagrams were subjected to second round of peer reviewing. Then, we applied some basic concepts from Network Science, e.g. clustering, core and periphery and small-world properties, to let students study the "topology" of their complex issue. We typically ended with a discussion of the possible impact of the dynamism inherent to complex issues. If time permitted, we asked students to come up with what if-scenarios and we invited them to regard the scenarios as pathways in a landscape of future outcomes.

The experiments taught us at least two important lessons.

First, we learned that ECW's could definitely enhance students' insights into their complex issue. The most obvious indicator was simply witnessing the students while they were creating their network diagrams. Network visualization urged them to think about connectivity and ambiguity. Moreover, it enabled them to share their thoughts with each other and start a dialogue. On some occasions, the dialogue led to new insights, e.g. missing links.

One student stated:

> "To me, the workshop was a real eye-opener. I am not very good at relating and integrating concepts and research findings. Thus, my research mostly results in lots of incoherent lists of findings. By connecting the dots, I gained far more insight."

In all programs except for the Honours Program, it was clear that this was a complete new way of approaching complex issues.

Second, we quickly discovered that we would need more workshop sessions if we were to give the aspect of dynamism the attention it deserves. In the majority of the experiments, creating systemic awareness and creating the "topology" network diagrams took up all of our time. Evaluating with regular course instructors, most of them expressed the need to properly address aspects of dynamism.

Conclusion and discussion

In this article, we argued that there is a compelling case for designing, testing and implementing embedded complexity workshops (ECW's) in Dutch higher professional education. In the real world, from the local to the global level, problems, challenges, systems, networks and developments are looking less like carefully constructed puzzles. Instead, they are looking evermore like intricate webs of related agents and factors. Businesses, governments and all other future employers of today's students, experience an increasing relevance and urgency to call on educational institutes to prepare students to deal with complex issues. It is safe to say that complexity has transcended the "buzz word era" in professional education.

In Dutch higher professional education, this call to action from students' future employers has left Universities of Applied Sciences searching for an optimal response. At Windesheim University of Applied Sciences, we were given the opportunity to set up experiments for new ECW's. We conducted plug-in workshops in various Bachelor programs, ranging from Journalism to Applied Gerontology. Overall, the workshops clearly fulfilled a need for students. Providing the tool of network visualisation helped many students to uncover connectivity and ambiguity in their complex issue. On various occasions, it also helped students to tackle information overload using the network diagram as a tool to order their research.

Though the workshops enabled students to study the *status quo* of their complex issue more effectively, the aspect of *dynamism*, which is inherent to our working definition of complexity, was not covered sufficiently. The topic of dynamism and uncertainty is going to be addressed in future workshops.

Another topic that could possibly lead to workshop re-design in the near future, is the question of transfer: which learning outcomes, if any, will be used by the students in the weeks after the workshop? Do students who experience new perspectives on complex issues change the way they actually operate in complex professional contexts?

Such questions notwithstanding, the introduction of complexity-informed perspectives in teaching programs in Dutch professional higher education is quite promising.

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