

Teaching Innovation in Interdisciplinary Environments: Toward a Design Thinking Syllabus

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Abstract:

An increasing number of universities offer user-centric innovation courses based on the principles of design thinking. Lecturers combine a plethora of design thinking elements in design thinking course syllabi and thereby adopt teaching styles that range from autonomy-supportive to structured. Using a balance between these two teaching styles seems most suitable to optimally engage students and provide guidance through the innovation process. To develop a syllabus for innovation courses, we draw on best practices currently being undertaken in universities worldwide and examine 11 design thinking syllabi from different departments (Engineering, Design, Business, and Information Systems). We identify 17 common and 18 unique elements of design thinking courses and related course materials. Based on our results, we propose a design thinking syllabus that includes suggestions for course objectives, course setup, assignment design, and team composition using a balance between autonomous-support and structural teaching styles.

Keywords: Design Thinking, Teaching Innovation, Course Syllabus, Interdisciplinary Lecture

I. Introduction

An increasing number of universities use design thinking as a method to teach user-centric innovation. This demand results from organizations who increasingly consider user-centric innovation as an important source of product or service innovation (Magnusson et al. 2003; Ordanini/Parasuraman 2011). Organizations are turning to design thinking to create new services at reduced costs, improve service acceptance, and obtain continuous innovation (Ordanini/Parasuraman 2011; Przybilla et al. 2018a). Design Thinking is a systematic yet intelligent process to generate and evaluate innovations that meet users' needs while satisfying a specified set of constraints.¹

Key principles of design thinking are a problem-based approach and an interdisciplinary team that will attack that problem by first establishing empathy towards the users (Dym et al. 2005). Accordingly, organizations now form design teams, ideally comprising members from different disciplines and cultures, that place the users' needs in the centre and apply (and if necessary adjust) the design thinking methodology (Dym et al. 2005). Universities have adopted design thinking in their curriculum and created interdisciplinary and cross-cultural courses to educate and train future innovators.

Lecturers have adopted different styles to teach design thinking. These styles follow different underlying philosophies that span between two poles: autonomy-supportive or structure (Jang et al. 2010). Lecturers who adopt an autonomy-supportive style engage students by facilitating an on-going congruence between students' autonomous sources of motivation and their moment-to-moment innovation activities (Jang et al. 2010). This teaching style supports students' internal perceived locus of causality, experience of volition, and sense of choice during learning activities (Reeve 2009). However, if students struggle with autonomy and do not take ownership, it is difficult to prevent disengaged students from becoming distracted, passive, or giving up easily in the face of challenge or difficulty (Jang et al. 2010).

Structure refers to the amount and clarity of information that lecturers provide to students about expectations and ways of effectively achieving desired educational outcomes (Skinner/Belmont 1993). A structured approach increases students' perception of competence, perceived control over valued outcomes, and self-regulated learning strategies (Sierens et al. 2009). Structured innovation processes, however, may inhibit radical innovation (Damanpour 1991).

To address complex problems during a design challenge, student teams conduct several iterations of prototyping and iteratively reflect their learnings in order to continuously improve their solutions (Dym et al. 2005; Buchanan 1992). To keep students motivated and prevent them from distracted or passive behaviour during their design activities, a design thinking syllabus must balance both poles: autonomy-supportive and structure. This research aims to develop a user-centric innovation course based on the design thinking methodology. The following question serves as guidance for the conduct of this research:

What current design thinking elements do lecturers of innovation courses employ?

We analyze 11 design thinking course syllabi from universities from different departments (e.g., information systems, engineering, business, design) across different continents. We use a qualitative content-analysis approach and validate our findings with lecturers at those universities. We identify common and unique elements of these courses including related course materials, course objectives, course setup, assignment design, and team composition. Further, we outline an innovation course syllabus and discuss how existing courses balance autonomy-supportive and structured teaching styles. This innovation course syllabus suggests elements to teaching design thinking to students of different departments, building on the most innovative techniques in current use by lecturers.

The remainder of the paper is as follows. First, we provide an overview of the fundamentals of design thinking and on the two different poles of teaching innovation. Next, we discuss our research methodology and the approach we used to investigate the collected syllabi. In the results section, we present our findings and outline our proposed course design. Lastly, we discuss and provide conclusive remarks on the contribution of our syllabus to the content of innovation courses in general and information system courses in particular.

¹ In contrast to the design science paradigm which follows the idea of prescriptive research achieving relevance through delivering prescriptions in the form of artefacts or technological rules, design thinking focuses on the human-centered creation and evaluation of tangible artifacts that meet user needs while being technical feasible and economic viable (Brown 2008).

II. Design Thinking

Fundamentals

Design thinking is a methodology to conduct human-centered innovation while ensuring technical feasibility and economic viability (Brown 2008). Innovation is human-centered when the needs of users drive development. A technically feasible solution builds on the strength of available technologies and team capabilities. To assure economic viability of design solutions, a clear value proposition needs to be identified and addressed. The design thinking methodology is applied across different disciplines and often applied to wicked problems in business, education, and society (Brown 2008; Johansson-Sköldberg et al. 2013).

A design thinking project is divided into problem and solution spaces, commonly referred to as the double diamond (Design Council 2007) (Figure 1). Within each space, a diverging (explorative) phase that widens the design space is followed by a converging (defining) phase that narrows the design space. A (design) challenge - a lead question that guides the innovation project through the entire life cycle - is the starting point into the problem space. Needfinding is used to get in touch with users and to discover needs related to the challenge. In order to synthesize the information gathered in the Needfinding phase, insights are formulated during the following converging phase. Insights provide the starting point for ideation and open up the solution space. The collection of feedback from user testing of prototypes allows converging towards a final solution or return into a prior phase to identify new needs, insights, or ideas.

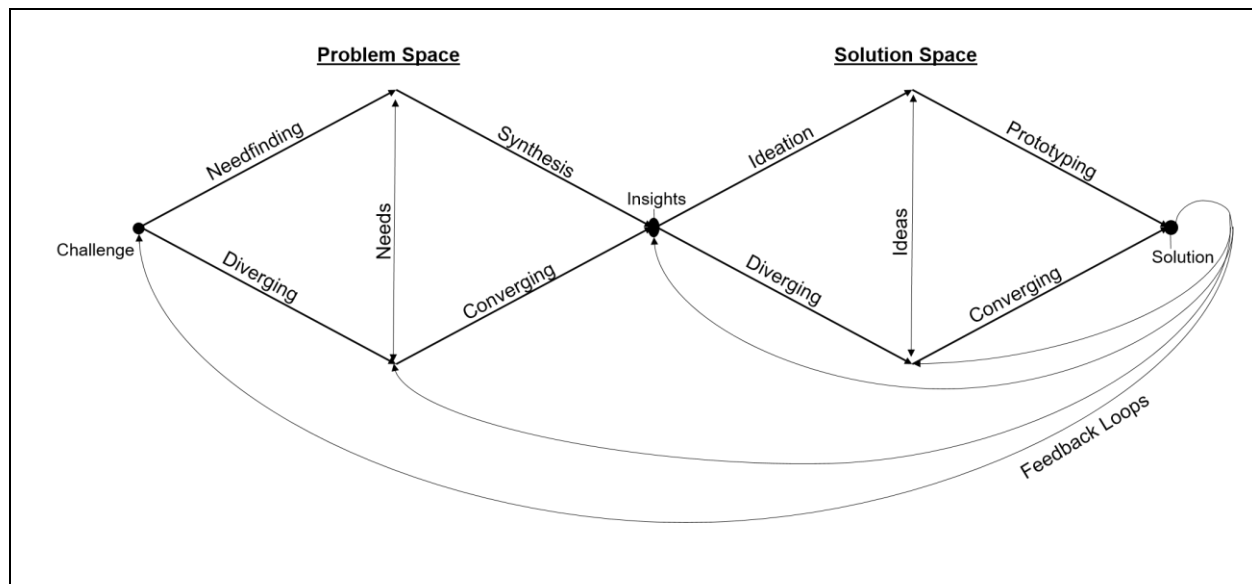


Figure 1. Design Thinking Double Diamond (adopted from Design Council (2007))

Design involves “changing existing situations into preferred ones” (Simon 1996). Design thinking teams use four broad principles during design activities (Table 1). First, design is *generative* in that it involves the creation of novelty (e.g., the “artificial”). To create novelty, design requires the creation of new knowledge or learning across a variety of design-related disciplines (Avital/Te'Eni 2009). Second, design is *iterative* since each newly generated artifact is subject to testing that thus informs subsequent design decisions. The design thinking team explores their design hypotheses and subjects them to a wide range of tests involving requirements, constraints, assumptions, cognitive schema, or multiple perspectives; the design evolves as a result of this process (Carlgren et al. 2016).

Third, these nested generate-test cycles occur in conjunction with *representations* and design artifacts themselves. The design thinking team explores alternatives and iterations across representations and learns about both the problem and the solution (Dorst/Cross 2001). Fourth, design activity is *complex* as it inevitably and unpredictably leads down unanticipated paths. The design thinking team uses different strategies including the hierarchical decomposition of the design (Simon 1996) or rich description of the design situation (Checkland 1981) to address these complex design activities. Design Thinkers simultaneously construct the problem space as they navigate the solution space. Although there are a variety of formulations of design thinking principles, most views are represented in these four principles (Gaskin/Berente 2011; Simon 1996).

Table 1. Principles of Design Thinking (adopted from Gaskin/Berente (2011))

Dimension	Related Themes	Description
Generative	Knowledge creation, learning, interdisciplinary teams, inter-cultural teams	It is critical to contextualize the creative aspects of idea generation within an overall design process during which the information gained from multiple alternatives informs the evolution of the design. The generative elements of a design process allow for the generation of design problems simultaneously with their solutions (Gaskin/Berente 2011).
Iterative	Generate-test cycles, abductive logic, fail fast	Throughout the design process design thinking teams explore alternatives through multiple series of continuous iterations. The evolving design manifests through a variety of iterations (Simon 1996).
Representational	Design artifacts, models, object worlds	Design thinking teams leverage a variety of representations to extend their own cognition and reflect on design activity in relation to a particular context in what can be described as a conversation with those representations (Schon 1992).
Complex	"Wicked" problems, intractable problems	Design involves solving problems that are not analytical questions of optimality. Rather, in all but the most trivial design tasks, design thinking teams deal with substantive, evolving questions with no definitive formulation and no final solution (Buchanan 1992).

Different teaching styles can be applied to teach these four design thinking principles (Deci et al. 1981). Next, we will outline these styles and discuss their advantages and disadvantages.

Autonomy-Supportive versus Structured Styles in Teaching Innovation

A lecturer's style of teaching innovation can be conceptualized along a continuum ranging from highly autonomy-supportive to highly structured (Deci et al. 1981). This view is based on self-determination theory which posits that autonomy drives motivation (Ryan/Deci 2000). The choice of teaching style influences the learner's inherent growth tendencies and innate psychological needs for autonomy that are the basis for self-motivation and personal integration (Ryan/Deci 2000).

In an autonomy-supportive teaching style, lecturers rely on three behaviours: (1) nurture inner motivational resources, (2) non-controlling information language, and (3) acknowledgement of the students' perspective and feelings (Reeve/Jang 2006; Ryan/La Guardia 1999). To nurture students' inner motivational resources, lecturers create opportunities for students to take initiative during learning activities. This means lecturers build instructional content around students' interests, preferences, personal goals, and sense of challenge and curiosity and do not put emphasis on external sources of motivation like incentives, consequences, or deadlines. Lecturers use a non-control style to provide explanatory rationales for requested tasks and communicate through messages that are informative, flexible, and rich in competence-related information. There is no emphasis placed on neglecting rationales or communicating through messages that are evaluative, controlling, or rigidly coercive. To acknowledge the students' perspectives and feelings, lecturers consider and communicate the value of the students' perspectives during learning activities and inquire about and acknowledge students' feelings.

When following a structured teaching style, lecturers rely on three other behavioural patterns: (1) presentation of clear, understandable, explicit, and detailed directions; (2) offering a program of action to guide students' ongoing activity; and (3) offering constructive feedback on how students can gain control over valued outcomes (Skinner/Belmont 1993; Skinner 1995). To establish clear and understandable directions, lecturers convey clear expectations with respect to students' future behaviour and prescribe ways for students to manage their moment-to-moment innovation activity during learning activities. Lecturers provide students with the leadership and scaffolding required to enable them to instigate and maintain effort toward achieving their goals and learning objectives. By offering constructive feedback, the lecturer helps students to further develop their skills.

Lecturers should combine both the autonomy-supportive and structured teaching styles to provide an effective learning experience for students. A lecturer-provided autonomy-supportive style is associated with the full range of student engagement (Ryan/Deci 2000). The lecturer-provided structure style of teaching is associated more narrowly with the on-task behavioural aspects of engagement (e.g., attention, effort, persistence) (Jang et al. 2010). A balanced use of both teaching styles can support student engagement during learning activities (Jang et al. 2010).

Student teams have to iterate and learn from previous iterations to address complex problems during the design thinking challenge (Dym et al. 2005; Buchanan 1992). To keep students motivated and prevent them from distracted or passive behaviour during design thinking activities, it is important to balance autonomy-supportive and structure teaching styles.

III. Methodology

We adopt a qualitative content-analysis approach in reviewing course syllabi related to innovation classes and evaluate our results by collecting feedback of from the lecturers responsible for each syllabus.

Since we need both, access to the syllabus and to the lecturers, we followed a purposive sampling strategy. We expect differences between disciplines because of different teaching backgrounds. This expectation led us to obtain syllabi from universities from different disciplines, e.g., information systems, engineering, business, and design. Because we believed cultural differences influence the teaching approach used to provide an effective learning experience for students, we further selected syllabi from different countries. To assure comparable results, we only focus on course syllabi that follow the above described principles of design thinking. Our final sample is presented in Table 2. Overall, we collected data from 11 schools, comprising 97 total pages (e.g., an average of 9 pages per syllabus and course materials).

Table 2. Innovation Course Syllabi Listing

School name	Country	Hosting Department	Student Background
Aalto University	Finland	Aalto Design Factory	Business, Design, Engineering
Karlsruhe Institute for Technology	Germany	Karlsruhe Service Research Institute	Business Engineering, Information Engineering and Management, Computer Science
Kyoto Institute for Technology	Japan	KYOTO Design Lab	Architecture, Engineering, Design
Paris-Est d.school	France		Engineering, Design
Pontificia Universidad Javeriana	Colombia	Design Factory Javeriana Cali	Engineering, Design
Stanford University	United States	Mechanical Engineering Department	Engineering
Swinburne University of Technology	Australia	Design Factory Melbourne	Business, Design, Strategy Innovation
Technical University of Munich	Germany	Chair for Information Systems	Business, Design, Engineering, Information Systems, Mathematics, Physics
Trinity College Dublin	Ireland	Robotics & Innovation Lab	Engineering, Computer Science
University of Modena and Reggio Emilia	Italy	Design Thinking Reggio Emilia	Business, Design, Engineering, Medicine
University of St. Gallen	Switzerland	Design Thinking HSG	Business

After collecting the available syllabi, we coded the documents to classify segments of text as a particular phenomenon (Miles/Huberman 1994). We coded the documents into four different categories: key phases, a series of design thinking elements conducted in the related key phases, learning objectives, and general information related to the course set up. We established a preliminary set of phases at the beginning of the coding process based on the design thinking double diamond (see Figure 1). One author coded a preliminary sample of syllabi, which a second author then reviewed. We discussed the initial approach and results and refined the phases. We then coded the remainder of the syllabi and, as we identified new phases in the data, iteratively defined the phases. We did not encounter any new coding categories at the end of the coding process suggesting we reached saturation in our classification.

We collected feedback from the responsible lecturers from each university to further establish validity of the artifact (Miles/Huberman 1994). In doing so, we provided each lecturer a summary of our coding results and asked them for feedback on our coding categories. These experts provided a series of helpful suggestions, which altered the structure and content of our suggested syllabus.

The results from this analysis allowed us to identify common and unique elements for an innovation course syllabus including course materials, assignment design, class format, and team composition. During the

coding we also identified topics or design thinking elements that we viewed as distinctive and valuable. We discuss these topics and techniques in detail in our Results section.

IV. Results

Operationalization of Design Thinking in University Classes

Syllabi across the different schools follow similar phases: To get started, the student team requires some basic instruction about the idea of the course, the design challenge, and teambuilding activities. In a next step, the student team conducts Needfinding and *explores* their *Design Space*. This phase is an ongoing phase in which the student team collects, synthesizes, and uses available information related to their design challenge. Next, *Critical Functions* are extracted from the problem space that need to be integrated into the ultimate solution. The *Dark Horse* phase explicitly moves the solution search outside of what might be normally considered reasonable; as a result, student teams often hit on successful solutions that were previously considered to be too “crazy” to use or implement. In the *Funky* phase, the most successful parts from the previous phases are connected and low-resolution prototypes are built.

The *Functional* phase includes the first concrete preview of the ultimate solution that integrates working functionalities. Within the *X-is Finished Phase*, one key functionality – the “X” – is fully implemented and tested. Such functionality should consider the core of the ultimate prototype. The *Final Prototype* phase includes the solution for one or several key identified needs and delivers the experience of using the real product. Figure 2 provides an overview of these phases.

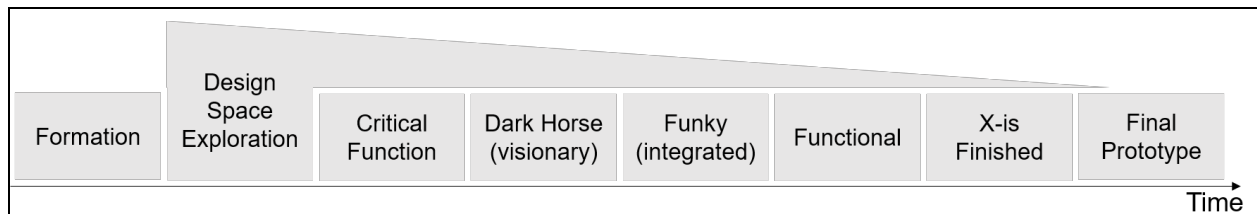


Figure 2. Design Thinking Course Phases

Within these phases, an iterative cycle of five steps is continuously iterated (Figure 3) (Vetterli et al. 2016; Hehn et al. 2018). The (current) definition of the problem is followed by the discovery of unarticulated user needs, which then inform ideation to develop new ideas. Prototyping and testing of these ideas allows for learning to what degree the targeted needs have been fulfilled, which allows for a new, more concise problem definition that restarts the cycle. Design thinking methodology provides a plethora of different elements that can be harnessed in each step of the process.

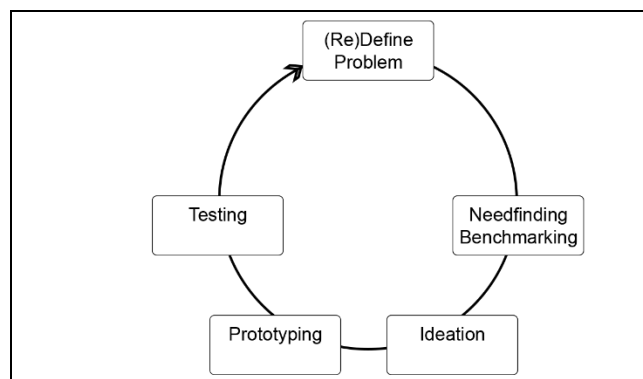


Figure 3. Design thinking micro cycle

Across the 11 syllabi, different departments adopt design thinking in different ways and set dedicated foci on design thinking elements. Mechanical engineering departments, like the ME310 course at Stanford University, put special emphasis on physical prototype development and related activities. Courses from business schools like the University of St. Gallen focus on business model innovation, and information systems departments, like that at the Karlsruhe Institute of Technology, prioritize rapid prototyping of digital services or agile project management methods. In order to identify the key concepts for an interdisciplinary innovation course following design thinking, we differentiate between common and unique elements for an innovation course syllabus.

Teaching Design Thinking: Common Elements

Based on our analysis, we identified the following common elements² for teaching innovation using design thinking. In addition to the description of each article, we synthesized relevant literature and corresponding learning objectives (Table 3). During the *formation phase*, students gain an overview of all design thinking activities and outcomes and the student teams are formed making team building activities important. As a common practice, a paper-bike challenge is conducted in which teams of students compete against each other in a race on self-constructed bikes that are built only from paper. Thereby, students (1) get to know one another and (2) apply the design thinking methodology for the first time on a task that results in early physical prototypes and is new to all participating students.

The *design space exploration phase* is an ongoing activity during which the student team collects existing information related to their design challenge. Included in this phase are design thinking elements such as desk research, interview research, personas, stakeholder map, benchmarking, idea napkin, and storyboard. As an example, personas describe archetypes of users using a representative name, face, and typical quotes for their related goals and needs. The student team tries to satisfy the persona's needs and goals during the design process.

The *critical function phase* is the first phase in which prototypes are built. Common elements for this phase are the distinction between high- and low-resolution prototypes and how appropriate testing activities are conducted. As an example, the student teams have to learn to start with low resolution (and sometimes unfinished) prototypes for the first testing activities. As the user needs are identified, the student team moves forward to higher resolution prototypes that cover novel solutions.

The *dark horse phase* consists of solution space exploration and assumption challenging as common elements. As an example, the solution space needs to be re-explored in order to identify out-of-the box solutions. This requires the student team to reflect on those implicit or explicit assumptions they used during their first prototyping phase. Such knowledge enables the team to go beyond existing solutions.

The *funky phase* consists of business model innovation as a common element. While the student team build their first combined low-resolution prototypes, business model innovation has to be thought. Such elements enable the student team to consider the business perspective related to their project and possible revenue streams that might be considered in subsequent prototyping iterations.

Table 3. Common Elements of a Design Thinking Syllabus

Phase	Common Element	Description	Reference	Learning Objective
Formation	Design thinking introduction	Overview on design thinking phases and outcomes.	(Dym et al. 2005)	Understand the fundamentals of the innovation method.
	Paper-bike challenge	Teambuilding activity in which groups of students build a paper-bike and compete against each other.	(Cutkosky 1998)	Develop social skills, shared values, and beliefs.
Design Space Exploration (ongoing)	Desk research	Collect existing information (e.g., solutions, ideas, learnings) in the context of the design challenge and relevant related areas.	(Garousi et al. 2017; Webster/Watson 2002)	Develop analytical skills related to the topic area of the design challenge.
	Interview research	Interviews accompany observation to elicit information from users about how they behave including their underlying rationale.	(Beckman/Barry 2007)	Understand and synthesize user needs and develop empathy for user group.
	Personas	A persona is an archetype of a user that is given a name and a face, and it is carefully described in terms of needs, goals and tasks.	(Cooper et al. 2009)	Structure empirical learnings and develop empathy to better understand diverging user needs.

² While these same elements are used in other phases, our results represent the common elements belonging to the core phase as identified in our coding process.

	Stakeholder map	A stakeholder map illustrates the rational, process or transactional perspective of all involved stakeholders. Identification of stakeholders is an iterative process where the stakeholder map is continuously enhanced to cover all relevant stakeholders	(Pouloudi/Whitley 1997)	Understand how different stakeholders interact and influence each other in the context of the design challenge.
	Benchmarking	Identification and benchmarking of market leaders considering market, technical, and business perspectives.	(Cooper 1998)	Understand how to transfer ideas from different domains or industries.
	Idea napkins	Idea napkin is a technique that is used to note ideas based on gathered insights and needs, and communicate these ideas in a structured way.	(Gasson/Waters 2013)	Document key learnings and ideas, and learn to build on other ideas.
	Storyboard	A Storyboard is a series of images, displayed in sequences, to visualize a process, service, or event.	(Tschimmel 2012)	Learn to combine ideas into a coherent user story.
Critical Function	Low and high resolution prototype	Starting with quick, low-resolution prototypes helps students diverge within the design space to avoid settling on solutions that might only be local maximum in the solution space and might not actually meet human needs.	(Vetterli et al. 2013)	Explore different ideas without simplifying the context, while focusing on specific and important needs within the design space.
	Testing	Testing and refining of developed prototypes result in an iterative process that allows for verification of initial assumptions and ideas.	(Sonnenberg/vom Brocke 2012)	Evaluate own ideas based on feedback and refine ideas building on empirical learnings.
Dark Horse	Solution space exploration	Understanding implicit and explicit assumptions within the innovation project.	(Alvesson/Sandberg 2011)	Identify assumptions underlying a topic area.
	Assumption challenging	Based on the solution space exploration, the boundaries and key-assumptions need to be challenged.	(Alvesson/Sandberg 2011)	Evaluate assumption and develop new idea that question assumptions.
Funky	Business modelling	Description of an innovative business model for the developed prototype.	(Osterwalder/Pigneur 2010)	Develop economic skills and get an understanding for business model innovation.
Functional	Revisit/ create personas and insights	Guided revision of developed personas to identify and select key-users.	(Cooper et al. 2009)	Develop skills and procedures to reflect and revise own results.
X-is Finished	User experience	Focus on users' experiences, especially their emotional ones. To build empathy with users, a design-centric project team observe behavior and draw conclusions about what people want and need as interacting with a dedicated prototype.	(Tromp et al. 2011)	Understand the differences between user-interaction and supporting functionalities or services.
Final Prototype	Reviewing Business model, storyline, and documentation	Review and evaluate outcomes based on provided requirements to improve the final prototype.	(Lee 1995)	Learn to take ownership for innovation projects.

Reflecting and revising the core elements from the design space exploration phase are common elements of the *functional phase*. While desk research and conducting interviews are ongoing activities, findings and learnings from the previous phases have to be synthesized and compared with previously developed personas and stakeholders. These elements help the student team to not only focus on the explicit user needs, but also identify implicit user needs that might not be as obvious.

The *X-is finished phase* requires elements focusing on user-centric solutions making user experience a key-element of this phase. The student team needs to understand which interfaces between product, service, or process exist and how they want to best use these interfaces. Furthermore, the student team needs to appreciate and recognize the importance of the concept of user acceptance, including ease of use and usefulness, as key elements within the design cycle.

The *final prototype phase* consists of reviewing tasks in different dimensions. During the design cycles the student team develops ownership of the project. To further encourage the team and to provide space for final feedback, a review of tasks coming from lecturers and industry partners is required. The student team now becomes enabled to finalize the prototype and relevant documents for hand-over to project stakeholders.

The unique elements of an innovation course syllabus are illustrated in Appendix I.

Table 4. Outline of Proposed Interdisciplinary Design Thinking Course Syllabus

Category	Interdisciplinary course details
Course objectives/ motivation	<ul style="list-style-type: none"> Students are able to apply the innovation method "Design Thinking" to describe and analyze real world problems Students can use elements within the design thinking methodology, apply them during innovation activities, and subsequently improve or expand those elements Students can plan, create, and develop human-centric innovations in a semi-structured way Students can evaluate their ideas and prototypes Students can work in international and interdisciplinary teams during innovation activities Students understand the central role of the innovation method "Design Thinking" for structured prototype development
Course setup	<p>Project sponsor: The project sponsor provides the design prompt, access to users and stakeholders, technical advice and feedback (when required) and financial support to assist with travel and prototyping costs. Project sponsors will typically be large companies, although there are successful exemplars from small companies/start-ups, non-profit companies, and other business units within universities</p> <p>Design thinking lab: A (semi-)dedicated space in which the student team can independently work</p> <p>Teaching team: Given the emphasis on the importance of different perspectives and knowledge bases on the student team, students should be presented with different perspectives and advice. Students need to learn to filter and balance this information – essential if they are to move past a "perform to the test" mentality. Members of the teaching team should be a mixture of faculty (with different specialties), teaching assistants, dedicated staff and "coaches" (e.g., course alumni or PhD students) who interact with the team in a less structured manner</p> <p>Social activities: Joint social activities such as SUDS (Slightly Unorganized Design Sessions) help students reflect and improve their ideas informally across student teams</p>
Student evaluation techniques	<p>Outcome-driven evaluation: Evaluate students based on project outcomes</p> <p>Process-driven evaluation: Evaluate students based on how they reach project outcomes</p>
Topic areas covered	One formation phase and seven core phases (Formation, Design Space Exploration, Critical Function, Dark Horse, Funky, Functional, X-is Finished, and Final Prototype) consisting of common (Table 3) and unique (Table 6, Appendix I) design thinking syllabus elements
Team composition	<p>Interdisciplinary: Students are selected from different departments to assure an interdisciplinary team. The disciplines within a team are aligned with the design challenge</p> <p>Intercultural: A partner team from an outside university is selected to stimulate the student team. The partner university within a team is aligned with the design challenge</p>

Proposing a Course Syllabus for Teaching Innovation

Based on our synthesis of the elements from each of the design thinking phases, we outline the syllabus for an innovation course that represents the key principles of design thinking and draws on the design thinking elements described above. The course is organized around one formation phase and seven core phases. Table 4 summarizes the content of the proposed course.

While we identify a high concurrence across all syllabi for the dimensions “Course objective”, “Course setup”, “Topic areas covered”, and “Team composition”, several different techniques are in use to evaluate students. Depending on the learning target of lecturers and departments, lecturers can apply an evaluation technique from a continuum between outcome-driven or process-driven. Outcome-driven evaluation focuses on reasonable outcomes and individual- and team- related learning. Process-driven evaluation uses a longitudinal perspective and evaluates intermediate outcomes, learnings from an individual or team perspective, or the team climate itself, usually on a weekly basis. Both evaluation techniques can be applied on a fine-grain or abstract level of evaluation criteria for students’ evaluation. Lecturers should choose a student evaluation technique that fits their own or their department’s learning targets.

V. Discussion

Reflections on teaching interdisciplinary innovation courses

The aim of this paper was to understand what current design thinking elements can be employed by lecturers of innovation courses to more effectively balance autonomy-supportive and structure teaching styles. We analyzed 11 design thinking course syllabi from classes offered by universities in different countries and disciplines. We identified 17 common and 18 unique elements of these courses, including related course materials and course objectives, course setup, assignment design, and team composition suggestions.

This paper contributes to teaching innovation by specifying a syllabus that addresses the general principles of design thinking, namely: generative, iterative, representational, and complex. Because design is generative and requires the creation of novelty, it is important to establish an interdisciplinary student team. To further foster the creation of knowledge and learning, our syllabus suggests common and unique design thinking elements for innovation courses, both of which enable the student team to learn necessary innovation elements from a methodology perspective.

We suggest the micro-cycle as a tool to be used iteratively in each design thinking phase as a means of fostering learning success and encouraging iterative improvements of the suggested solutions. The representational dimension is accomplished by adopting a real-world challenge provided by a corporate sponsor engaged as product owner in the design thinking project. Lastly, to break down complexity within wicked design thinking challenges, we recommend that the student team run through the each of the design thinking phases. Each phase has its own aims and provides a structure for the student team to effectively address the design challenge. Table 5 summarizes how our syllabus addresses the design thinking principles.

Table 5. Design Thinking Principles addressed in the Design Thinking Syllabus

Dimension	Related Themes	Design Thinking Syllabus
Generative	Knowledge creation, learning, interdisciplinary	Interdisciplinary and inter-cultural team composition, common and unique elements
Iterative	Generate-test cycles, abductive logic, fail fast	Micro-cycles
Representational	Design artifacts, models, object worlds	Real-world challenge, corporate partner, course set up
Complex	“Wicked” problems, intractable	Design thinking phases

The syllabus we propose considers the micro-cycle and design thinking phases to balance autonomous-supportive and structure teaching styles. The student team iterates through the micro-cycle several times during the innovation project to become familiar with it. During these iterations, the student team can tailor their individual tasks autonomously without relying on a strict structure. This more relaxed process can promote student engagement through ownership of the design challenge, allow more individual input and situational preferences, and provide the student with the opportunity to acquire capabilities required in a

dynamic environment. Design thinking challenges are by nature wicked problems and students may fear disengagement (Buchanan 1992). To overcome this problem, our syllabus suggests eight design thinking phases that the student team should follow. This structure provides a clear path to forthcoming innovation activities and feedback on their progress in terms of reaching expected outcomes related to the design challenge.

The micro-cycle provides autonomy by enabling students to put emphasis on their own preferences to address a distinct sub-challenge. While the micro-cycle suggests five steps, the student team defines their own focus depending on their progress through the design phases. For example, during the design exploration phase the student team places special emphasis on (Re-)Define Problem and Needfinding. During the X-Is finished phase, students rely more on prototyping and testing activities. From a pedagogical perspective, the student team is able to adjust the circulation time depending on their current learning situation. While an experienced student team may iterate slower by having a deep-dive within each micro-cycle phase, a novice student team may speed up the circulation time to foster experimental learning on a methodology level.

Another important source for autonomy of the student team is the team composition itself. Innovation activities and team formation happen in a global context. Consequently, the student teams must learn to coordinate their activities over distance, languages, time zones, and cultures. The team is therefore challenged to develop procedures, schedules, and tools to overcome these potential obstacles. Composing such teams requires that team formation and core design thinking phases last longer due to the increasing amount of coordination and alignment tasks, which in turn, increase the learning experience for students.

The design thinking phases provide structure by pointing out a clear and understandable direction for the student team. Each phase has a dedicated and well-communicated aim that the student team is expected to reach. By receiving continuous feedback from lecturers, the student team is better able to diagnose and evaluate their current progress within the design thinking challenge and, if required, adjust their activities to reach desired outcomes. The design phases have another structural advantage: the student team can diagnose those skills it currently possesses and those it may attain in the future. Should the student team lack specific skills, distinct learning activities can be added to the syllabus. Lastly, the design phases motivate the student team by providing a clear timetable with a fixed project endpoint.

The design challenge influences the focus of the student team during the micro-cycle. We identified three different types of design challenge targets: physical innovation, service innovation, and digital innovation. Design challenges for physical product innovation aims to produce tangible, low-resolution prototypes in early stages to collect early user feedback. This enables the student team to better understand user needs and iteratively address them. Service innovation challenges tend to focus on user-experiences during developed services. By focusing on user experience, the student team can evaluate if the suggested service processes address user needs and motivate them to participate in the suggested solution. Digital innovation challenges emphasize the potential and user-interaction of distinct technologies. The aim of digital innovation is to select appropriate technologies and assure technology acceptance for the final prototype.

This syllabus serves as a starting point for different departments and disciplines with different learning-targets to set up innovation courses. Depending on the existing core-competencies of lecturers and departments, the common elements can be used as a basis in innovation courses while the unique elements can be adapted and implemented as required. Universities, lecturers and departments have different learning targets and may use different methods to evaluate attainment of targets. While outcome-driven evaluation techniques tend to support autonomous learning-targets, process driven evaluation techniques support procedural learning targets. While we recognize that our proposed course may not be ideal for all departments, students, or lecturers, we believe it provides a skeleton for teaching innovation and allows lecturers to tailor it to their situation.

The Future of Teaching Information System Courses

Existing information systems course designs might benefit from an interdisciplinary course syllabus such as the described innovation courses. The roots of information systems can be found in business administration and computer science. Similar to innovation projects that combine different disciplines (e.g., informatics and design), information systems projects would benefit from interdisciplinary teams to simulate real world environments. More important, students benefit from interdisciplinary teams. While teaching interdisciplinary teams may be more challenging than teaching teams belonging to one discipline, the knowledge and insights to be gained by students through exposure to other disciplines could prove invaluable.

Incorporating real-world challenges into the teaching of information systems enhances learning through practical examples. In fictive challenges, students miss important information that are normally provided from users and have difficulties in creating mutual understanding of the challenge itself. Students must shift the focus from a technology-oriented perspective to a user-oriented perspective. Only when the real needs of users are addressed, and the final solution is properly designed in terms of user understanding can students develop skills required for post-university employment.

This study is subject to limitations. First, we see design thinking as a structured way to approach innovation. However, lecturer may also apply other methods such as the LEAD user method in innovation classes that follow different philosophies than our structured approach. Second, our sample included syllabi from 11 different universities. Hence, this sample may not be representative of a large community of innovation courses. Since we drew our sample from different universities worldwide and investigated syllabi from different disciplines, this study should provide a starting point to further develop innovation course syllabi. Third, while we have anecdotal evidence based on existing design thinking syllabi, we do not formally evaluate our proposed syllabus. Future research could evaluate learning objectives and progress of students in design thinking courses.

VI. Conclusion

In this paper we developed a syllabus for innovation courses based on the design thinking methodology. To keep students motivated and prevent them from distracted or passive behaviour during their design activities, our design thinking syllabus balances autonomy-supportive and structure teaching styles.

We investigated 11 syllabi from innovation courses around the world from different departments and identified one formation phase and seven core phases (Formation, Design Space Exploration, Critical Function, Dark Horse, Funky, Functional, X-is Finished, and Final Prototype) consisting of 17 common and 18 unique elements of design thinking courses. Based on our results we propose a design thinking syllabus that includes suggestions for course objectives, course setup, assignment design, and team composition using a balance between autonomous-support and structural teaching styles. Our syllabus provides an overall foundation for teaching innovation and allows lecturers to tailor it to their situation.

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Appendix I – Unique elements of an Innovation Course Syllabus

Schools vary in their focus to teaching innovation (Scheer et al. 2012; Dym et al. 2005). Table 6 outlines unique elements of a design thinking syllabus that can be individually adopted.

Table 6. Unique Elements of a Design Thinking Syllabus

Phase	Unique Element	Description	Reference	Learning Objective	Coded Department
Formation	Agile project management	Agile is a project management methodology that uses short development cycles called “sprints” to focus on continuous improvement in the development of a product or service.	(Schwaber 2004; Przybilla et al. 2018b)	Learn to work in project teams on a user-centric and iterative procedure including clear responsibilities.	Information Systems
	Ethnographic research	Ethnography entails examining the behavior of the participants in a certain specific social situation and understanding their interpretation of such behavior.	(Hammersley/Atkinson 2007)	Develop a deep understanding of users' current situation and needs before moving to the creation of solutions.	Business, Design, Information Systems
Design Space Exploration (ongoing)	Survey research	The broad area of survey research encompasses any measurement procedures that involve asking questions of respondents.	(Alreck/Settle 1994)	Develop an understanding of how the relationship of independent and dependent variables can be examined.	Information Systems
	Brainstorming	Brainstorming is a group process applying techniques that promote the search for new solutions that might not be possible through individual ideation.	(Sutton/Hargadon 1996)	Learn how to build on team member's ideas.	Business, Information Systems, Engineering
	Six thinking hats	Six thinking hats describes a tool for group discussion and individual thinking involving six colored hats.	(De Bono 2017)	Understand the importance of different critical perspectives on solutions and ideas.	Business, Information Systems
	Trend mapping	A visual depiction of relevant trends influencing the system around the design challenge.		Understand interrelations between observations, e.g., external factors, or shifts in social norms.	Business
	Sketching	A sketch is a rapidly executed freehand drawing that is not usually intended as a finished work.	(Buxton 2010)	Develop skills to focus on and communicate the key-aspects of an idea.	Design, Business
	Requirement engineering	Requirements engineering refers to the process of defining, documenting and	(Van Lamsweerde 2009)	Understand how requirements evolve, can be	Engineering, Information Systems

		maintaining requirements in the engineering design process.		structured, and synthesized.	
Critical Function	Visual thinking	Visual thinking is the phenomenon of thinking through visual processing.	(Ware 2010)	Understand how visualization can foster ideation processes.	Design
	Hunting plan	Project plan including a detailed time-table and milestones.	(Burke 2013)	Develop project management skills.	Business, Information Systems
	White horse prototype	Building prototypes without any pre-knowledge to set up a threshold for future (innovative) solutions.		Develop benchmarking skills during the entire design thinking process.	Design, Engineering
Dark Horse	Platform thinking	Platform thinking is a process of identifying and exploiting commonalities among an organization's offerings, target markets, and the processes for creating and delivering offerings.	(Halman et al. 2003; Schrieck et al. 2017)	Understand how platform business models can be developed and applied.	Business, Information Systems
Funky	Business model navigator	55 patterns provide the blueprints to innovate business models.	(Gassmann et al. 2014)	Understand patterns of different business models and how to apply these to existing solutions.	Business, Information Systems
	Service design	Service design uses the design process as a means to enable a wide range of disciplines and stakeholders to collaborate.	(Erl 2008)	Develop a service-oriented understanding of customer integration.	Information Systems
	Gamification	Gamification refers to the use of game design methods as a means to leverage games for business benefit.	(Deterding et al. 2011)	Develop an understanding of how users' engagement can be improved.	Business, Information Systems
Functional	Technology implementation (Arduino, programming, Kinect etc.)	Teach technology implementation and programming to enable digital prototyping.	(Faludi 2010)	Develop hard- and software prototyping skills.	Information Systems
X-is finished	Storytelling	Storytelling improves the novelty and value of generated ideas by helping decision-makers take in and hold onto the rich details of the lives of those for whom they seek to create value.	(Delgado 1989)	Develop communication skills.	Business, Design, Information Systems, Engineering
	Shark tank	In a shark tank student teams pitch and defer their ideas in front of an expert panel.		Develop communication and presentation skills.	Business