The Pedagogical Challenge of Interdisciplinary University Programs

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Abstract

Multi- and interdisciplinary education is currently being widely discussed and promoted in the academic world. Several interdisciplinary programs are being created, and new curricula are being formed. However, the terms multi-, inter- and transdisciplinarity are being exploited carelessly, without taking a closer look at the theoretical framework or the vast literature on the topic that is commonly accepted by interdisciplinarians.

In academia, where the segregation and ever-deepening expertise of disciplines over decades has produced siloed structures of faculties and departments, it is difficult to facilitate interdisciplinary studies that genuinely integrate disciplinary insights. Part of the problem in academia can be seen as inconsistencies in pedagogical thinking. Traditionally, researchers and university teachers are expected to be specialists in the substance of their discipline. Only recently have pedagogical studies become available and offered to faculty members, which is likely to increase the level of pedagogical rigour in higher education. However, the contemporary challenges faced in organizing cross-disciplinary teamwork and education can be assumed to partly arise from the inadequate pedagogical training of university teachers.

This paper presents some of the challenges and problems that are commonly encountered when attempting to bridge disciplines in a university context. It draws on the processes that took place in Aalto University and its preceding universities, particularly Helsinki University of Technology. A closer look

is taken at the collaboration between the disciplines of architecture and engineering. Some aspects of the phenomenon are reviewed from a theoretical viewpoint, in an attempt to better understand the various perspectives and alternative ways of knowledge creation when organizing the design and implementation of interdisciplinary curricula.

Keywords: Interdisciplinary studies, complex systems, situated learning, teamwork, collaborative models

Introduction

Multi- and interdisciplinary education is currently being widely discussed and promoted in the academic world. Several interdisciplinary programs are being created, and new curricula formed. One might even argue that multidisciplinarity has come to resemble a mantra, repeated excessively, sometimes without taking a closer look at the most appropriate pedagogical approaches, implementations and benefits. The terms multi-, inter- and transdisciplinarity are exploited carelessly, without taking a closer look at the theoretical framework or the vast literature on the topic that is commonly accepted by interdisciplinarians. Some critics, like Wasserstrom (2006), even argue that that interdisciplinarity has become so "fuzzy" that universities' commitment to it is close to meaningless. Undoubtedly this stems from the fact that the challenges and complex problems of our time desperately call for greater collaboration and integration of insights, knowledge and disciplinary practices. For example, the questions of development in the world majority context (i.e. the third world or the developing countries) are broad in nature and cannot be addressed with a single or few areas of expertise. The same applies to the environmental and climatic challenges we are currently facing (Hollmén et al., 2014). Contemporary problems cannot be solved with the instrumentalities of the past; integration of disciplines and new forms of knowledge creation are needed (Hollmén & Rose, 2013).

Interdisciplinarity needs to be incorporated into the fundamental thinking of curricula design, as well as the research agendas of contemporary academia. The question remains: How to bridge the disciplines in such a way that new insights and understanding are created, rather than mandatory curricula requirements superficially fulfilled?

In academia, where the segregation and ever-deepening expertise of disciplines over decades has produced a siloed structure of faculties and departments, it is difficult to overcome the commonly accepted and customary modus operandi. The division of the scientific community into ever smaller units as a result of expansion of expertise has generated a new type of challenge: How to create an understanding of the relations between the diversifying types of knowledge and their sharable insights? Stepping out of the ordinary, looking and reaching for the "big picture" to see how things connect, to find new ways of working and taking the trouble of doing things in a different way, is time consuming and laborious. Klein (1999) aptly refers to an old saying: "Trying to change a curriculum is more difficult than trying to move a cemetery."

Part of the problem in academia is the scarcity of pedagogical thinking. Traditionally, researchers and university teachers are expected to be specialists in the substance of their discipline, as research is valued more than education – as is indicated by the proportion of funding by which education and research achievements are measured in universities. Only recently have pedagogical studies become available and offered to faculty members, which is likely to increase the level of pedagogical innovation in higher

education. However, the contemporary challenges faced in organizing cross-disciplinary teamwork and education can be assumed to partly arise from the inadequate pedagogical training of university teachers.

This paper presents some of the challenges and problems that are commonly encountered when attempting to bridge disciplines in a university context. It draws on the processes that took place in Aalto University and its preceding universities, particularly Helsinki University of Technology. A closer look is taken at the collaboration between the disciplines of architecture and engineering. Some aspects of the phenomenon are reviewed from a theoretical viewpoint, in an attempt to better understand the various perspectives and alternative ways of knowledge creation when organizing the design and implementation of interdisciplinary curricula.

Mapping Collaborative Academic Models at Aalto University

Aalto University was created in 2010 by merging three established universities: Helsinki University of Technology, Helsinki School of Economics, and the University of Art and Design Helsinki. When Aalto University School of Arts, Design and Architecture was created in 2012, it combined the former departments of the UIAH and the Department of Architecture, thus separating the Department of Architecture from the Faculty of Engineering. In the former Helsinki University of Technology, some difficulties had already been encountered in organizing collaboration and bridging the two disciplines of architecture and engineering. As a prerequisite for the formation of the new school, the president of the university requested that the collaboration between architecture and engineering be developed and deepened.

The process was launched with a vast enquiry in which at least a hundred faculty members, all of whom were experienced university teachers and/or researchers, took part. The mapping of the phenomena took one year, during which the tacit knowledge of the faculty was collected – experiences and attempts at collaboration from the past and the present – in order to demonstrate the difficulties, challenges and successes of bridging disciplines.

Successful examples of research and education crossing disciplines were identified, especially between architecture and land use planning and urban studies, as well as in the Wood Program, which is a research and design platform for exploring the properties of wood (Hollmén & Paavola, 2012). Most difficulties were found in combining the teaching of both structural and mechanical engineering with architecture – despite the fact that by default these disciplines work closely together in all construction projects. Students entering the construction business after finishing their diplomas will automatically be put to work in teams with members from these disciplines, yet academia had failed to educate them in teamwork and commonly created innovations. The greatest challenges were found in curricula design, teamwork coordination and persistent sequenced design processes. Time for common courses was difficult to find, and when collaboration was attempted, the teamwork was problematic as the course assignment was

organized in a sequenced manner, implying that one discipline would wait until the other had produced material for the others to work on (Hollmén & Paavola, 2012).

To move forward from mere observations, a year-long process of coordination was initiated. During the academic year 2012-13, Saija Hollmén (Aalto University Dept. of Architecture) and Chris Rose (Rhode Island School of Design) studied the possibilities of further developing a new intellectual and pedagogical framework for collaboration between Aalto Schools of ARTS and ENG. The results of the study are presented in the final report by Hollmén and Rose (2013) *ARTS + ENG: Future Collaborative Academic Models at Aalto.* The report took a practical approach to offering alternatives to extend the cooperation between disciplines in the Aalto School of Arts, Design and Architecture (Aalto ARTS) and School of Engineering (Aalto ENG). To further enlighten the issues touched on in the report, this paper looks at some of them from a theoretical point of view, to scaffold and frame them to allow for a deeper understanding of the challenges.

Definitions of Interdisciplinarity

The terms multi-, inter-, and transdisciplinarity are often confused, without clarity about the terminology. A literature review provides various and extensive definitions on the differences between the terms. Since 1979, the Association of Interdisciplinary Studies (AIS) founded at Oakland University, Michigan, has promoted the interchange of ideas among scholars and administrators to further integrative studies (AIS website). AIS's publication Issues in Interdisciplinary Studies, as well as AIS's annual conferences, have become an important forum of contemporary knowledge creation and sharing for interdisciplinarians. The literature also provides useful definitions of the terminology commonly used.

Repko (2007) sees multidisciplinary as proximity: placing two or more disciplines side by side, such as inviting teachers from different departments to explain the perspective of their discipline for the course issue in a serial manner, but not necessarily intertwining or integrating their insights. It uses the knowledge understanding of more than one discipline, without necessary allowing for integration (Ibrahim et al., 2007). Repko (2007) argues: "Merely bringing the different disciplines together in some way but failing to engage in the hard work of integration is multidisciplinary studies, not interdisciplinary studies" (p. 133).

Interdisciplinarity uses the epistemology methods of one discipline within another (Ibrahim et al., 2007). It draws on more than one discipline's perspective to synthesize a more comprehensive understanding (Newell, 2001). As early as in 1997, Klein and Newell provided what has served as the basis for the definitions of interdisciplinarity: "Interdisciplinary studies may be defined as a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession" (p. 393).

Multidisciplinarity is entirely subsumed within interdisciplinarity; it is a necessary but insufficient condition for interdisciplinarity (Newell, 2001). Interdisciplinary or integrative studies occur when teachers go beyond establishing a common meeting place to develop new methods and theory crafted to transcend the disciplines in order to solve problems (Newell, 2001; Repko, 2005). Organizing interdisciplinary curricula requires an understanding of certain aspects of the basic elements of human behavior in relation to teamwork, knowledge creation and social systems. It is an extremely demanding form of education, which can also have detrimental effects if not properly designed and facilitated. According to Repko (2007) the basic requirements of an interdisciplinary course include:

> "(1) addressing a complex problem or focus question that cannot be resolved by using a single disciplinary approach, (2) drawing on insights generated by disciplines, interdisciplines, or schools of thought, including non-disciplinary knowledge formations, (3) adhering to integrative process, and (4) producing an interdisciplinary understanding of the problem or question" (p. 131).

Students demonstrate interdisciplinary understanding "…when they integrate knowledge and modes of thinking from two or more disciplines in order to create products, solve problems, and offer explanations of the world around them" (Boix Mansilla et al., 2000, pp. 17-18). The common misapprehension is that interdisciplinary interaction happens when students of different disciplines are put to work on a problem together. If professionals working in the field find it challenging, it is not likely to be any less demanding for students, who are still refining their professional skills. The challenging task of the teacher is to facilitate the interaction: interdisciplinary collaboration does not happen by itself. It requires active engagement and the "crafting of opportunities" wherein the students can find out for themselves what each other knows, how one's own knowledge can contribute to the task at hand, and how these threads of knowledge are woven together to create new thinking.

Transdisciplinarity is said to be a meta-level approach to interdisciplinarity, which involves multiple disciplines, *and* the space between the disciplines *with* the possibility of new perspectives "beyond" those disciplines (Ibrahim et al., 2007, pp. 91-92). It engages students to investigate real world problems by using several disciplines, and to discover the non-disciplinary and emerging knowledge "in between" the disciplines. As its best, teacher-facilitated interdisciplinary collaboration has the potential to rise above expectations and explore the knowledge found in between the established fields, thus creating authentic innovations.

Complex Systems

Interdisciplinarity is frequently paired with complexity. In his article A Theory of Interdisciplinary Studies, Newell (2001) contends that "…complex systems and phenomena are a necessary condition for interdisciplinary studies" (p. 1). Thus, as noted also by Repko (2007), complexity can be understood as a keyword in the contemporary description of interdisciplinarity. An interdisciplinary course focuses

on a problem which cannot be addressed with a single disciplinary approach, nor by using two side by side, or in a sequenced manner – i.e. on a problem that is complex in nature. An interdisciplinary course by default needs a challenge that allows and requires not only integration of perspectives, but holistic thinking and a possibility for innovative knowledge creation. Repko (2007) argues, that "…whereas perspective taking is the ability to understand how each discipline would typically view the problem, holistic thinking is the ability to see the entire problem in relation to its constituent disciplinary parts" (p. 134). A system is a set of nonlinear relations of separate facets of a problem. Newell (2001), in fact, claims that: "…a complex system is composed of components actively connected through predominantly nonlinear relationships" (p. 9). Viewed from one disciplinary vantage point, the components of a system appear differently than when seen through another perspective. Furthermore, a system changes as the relations of its components evolve. Newell (2001) asserts that: "All systems… are made up of components that interact… Because of those interaction effects, the system as a whole is more than the sum of its parts; indeed, it is different from the sum of its parts" (p. 7). The pedagogical challenge in an interdisciplinary course dealing with complex systems is to sense the emerging relations and undefined connections, and to allow them to evolve freely in pursuance of structuring the course in a meaningful way.

As is commonly agreed by the interdisciplinarians, interdisciplinary courses that operate in the framework of a complex system become a *process* rather than a *product*. Newell (2001) discusses the nonlinearity of this interdisciplinary process: "Integration necessitates working backward from the phenomenon and forward from the sub-systems studied by different disciplines. That integrative process is anything but linear" (p. 20). The nonlinearity and indeterminacy of human behavior as a complex system challenges education, and forces the faculty into constant debate about the didactics of the issues taught and the planning of education.

On the other hand, Klein (1999) presents a fairly linear approach to interdisciplinary steps. Although useful in natural sciences and applicable in humanities, taking into account the nature and essence of arts, design and architecture, interdisciplinary processes including these disciplines can hardly be determined as linear rather than cyclic, iterative, self-sustaining and dynamic. New combinations affect and create nonlinear relations within and between systems, creating novel perspectives and unforeseen situations. Each combination produces a different setting and a network of relations. The pedagogy arising from these relations needs to accommodate itself to the prevailing and constantly changing settings.

Local knowledge plays an important role in understanding the specific features of a complex system (Newell, 2001). Based on my experiences of architectural and environmental development, for example in Rwanda (Pääkkönen, 2014), complex problems, like development, are strongly connected to locality and human behavioral systems. Local knowledge is needed in order to understand a community and to identify the common aspirations and local understanding of development and prosperity – as defined by the community itself, not by external actors. Local knowledge is of utmost importance: people's behavior in a cultural environment is defined by a cultural coding system, which varies significantly from place

to place. Any scientific or behavioral experiment only has relevance in its respective cultural context – people may be the same everywhere, but the cultural coding according to which people behave differs substantially. Thus, from the experiences I can argue that as a representation of the complexity of a cultural system, architecture is a reflection of customary and cultural coding. Architecture, art and design can be used as a vehicle for combining contemporary scientific innovations in the creation of culturally and locally relevant and sustainable environmental improvements.

Interdisciplinary studies also bring forward the possibility to engage students from industrialized countries in the world majority context in a reciprocal manner. Organizing such endeavors requires significant investment from universities. Travelling, with all its costs and cumbersome practicalities, is necessary to get an embodied cognition of a place and a culture. Gaining holistic understanding of a phenomenon is not merely a literature exercise: non-disciplinary knowledge creation is as important in education as is scientific rationale.

An outstanding example of complex systems being studied through interdisciplinary approach is the Innovation Studio at Rhode Island School of Design (RISD), led by Professor Charlie Cannon. It is an interdisciplinary initiative that typically tackles large-scale environmental or infrastructure problems, like redesigning New York City's entire waste stream, or climate change, or designing sellable products from agricultural waste (Industrial Designers Society of America website). The studio invites industrial design, landscape architecture, and architecture students to take part, and they start by building a common knowledge basis of the phenomenon at hand. Drawing on their disciplinary backgrounds, the students combine their expertise and imagine the most comprehensive solution to the problem. The challenges are complex and deal with sustainability and social innovation. The Innovation Studio brings the academic world to real life, thus preparing the students to deal with large-scale systemic and complex problems as alumni.

Arts Letters & Numbers (ALN) is a multi- and interdisciplinary program where large and undefined problems are looked at from various perspectives. Run by Professor David Gersten from Cooper Union and RISD, ALN explores the boundaries of knowledge, engages in new forms of education, and draws from the various areas of arts, science and humanities. It is a process of creating an understanding of the world, unforeseen and unpredictable as life itself.

> "Arts Letters & Numbers is a non-profit arts, education and publishing organization dedicated to creating creative exchange across a wide range of disciplines, including Architecture, Visual Arts, Theatre Arts, Film, Music, Humanities, Sciences and Social Sciences. Arts Letters & Numbers conducts workshops in educational and cultural institutions worldwide in collaboration with theatre companies, artists, writers, actors, musicians and filmmakers. It operates an ongoing series of educational workshops, performances, and film productions." (ALN)

As an emerging structure, Art Letters & Numbers is a promising forum for investigating new ways of education and knowledge creation, as it is"…opening spaces within broad human and disciplinary geographies; spaces of participation, of communication, of reciprocity, for people and their works to listen to each other, to listen to the world." These examples create new and inspiring horizons from which we can all learn when exploring possibilities for new ways of knowledge creation and interdisciplinary pedagogy.

Situated Learning

Architectural education in Finland is known for its pragmatic approach to teaching. Strong emphasis is traditionally placed on practical matters – students are taught to design buildings, cities and land use, and understand historical values and restoration. In a traditional design studio, learning often happens within the framework of a course that simulates reality: course material includes a real site, a program, and a "client". The students learn the basics of a design process by trial and error; "learning by doing" is a commonly used teaching strategy, appreciated by many.

"Learning by doing" has a strong connection to situated learning theory and the idea of community of practice (Wenger, 1998). Situated learning theory implies that *learning* is becoming a member of a community of practitioners, and *knowledge* is the ability to participate in a community of practice (Clancey, 1995). Action is situated because it is constrained by a person's understanding of his or her "place" in a social process (Clancey, 1995). Lave (1991) suggests we should "…consider learning…as a process of becoming a member of a sustained community of practice" (p. 65).

To teach is to change a social system in which the activity occurs. In interdisciplinary studies the representations in communities of practice are questioned, as the social systems of a certain community of practice are not valid in a new set of nonlinear relations. A new system, a new community of practice and practitioners are formed in interdisciplinary interaction. Clancey (1995) mentions that the strongest effect is not in "how to teach", but in "how to change" a social system. Holistic thinking and the interdisciplinary integration of perspectives transforms the social systems of communities of practice. Learning in interdisciplinary studies is situated, as it stems from the activity that takes place in the changing social system and new community of expertise and practitioners interacting.

In university education, students quickly learn to adapt to the conventions of their particular community. Participating means knowing the conventions of a particular society, and as a social system, the society has its own representations of actions, which become internalized by its members. This in turn sustains

the division between disciplinary communities. Creating interdisciplinary programs is challenging due to the differences in behavior between established communities of practice in the university context.

Sequenced or Simultaneous Design Processes

Attempts to bring students together for multi- and interdisciplinary courses in the university context have often resulted in failure, when the coordination between different threads of information has been insufficient. In tasks where students have to perform their part in sequences, overlapping schedules and division into sections has caused some of them to wait for others to perform before they can take their turn to provide the portion of knowledge and expertise they are to bring to the task at hand (Hollmén and Paavola, 2012). The sequential approach causes frustration among the ones who wait, and exhaustion among those who work under pressure to complete their share in time. No real change in ideas emerge, and no new innovations are made. Disciplines are kept separate, even though the course is technically referred to as being multidisciplinary.

This sequential approach is particularly characteristic in the field of building design. In a traditionally coordinated building design process, the architect starts the process by negotiating with the client about the needs and aspirations the building is to meet. The preliminary architectural sketches are then discussed with the client, and alterations are made according to those conversations. (In the university context the client is often replaced by the teacher, who comments on the architectural qualities of the design.) The next disciplines to enter the project are structural and mechanical engineering, with whom the project starts to become more complex and realistic. Construction and project management, and life cycle analysis are brought in at a later stage, if at all.

Although the architectural solutions largely define the overall concept of the finished product, as well as the quality of the built environment, neglecting the other related disciplines in the early stages of a building design process has its obvious defects. Structural and mechanical engineering as well as life cycle analysis have become highly complicated and demanding areas of expertise, and the solutions chosen for these areas increasingly affect the end result. Should they be included in the very beginning, one could expect better integration of overlapping systems and technologies in the building, resulting in high quality architecture. All in all, one can claim that the sequential approach to building design is an outdated procedure, whereas the reality today calls for the integration of disciplines from the very early stage of the design process.

In the PBL lab at Stanford University, Professor Fruchter has developed a complex program called AEC (Architecture/Engineering /Construction) Global Teamwork, where students from respective disciplines work in teams to design and plan a complex building. Fruchter (2001) writes:

> "(AEC Global) Teamwork is the process of reaching a shared understanding of the design and construction domains, the building to be built, the design process itself,

> and the commitments it entails. The understanding emerges over time as each team member develops an understanding of his/her own part of the project and provides information that allows others to progress. The process involves communication, negotiation and team learning." (p. 427.)

All students need to maintain a constant, high level of engagement in the project and have a well-defined responsibility to represent their profession within their team. All team members participate in the concept formation from the very beginning, allowing their disciplinary perspectives to contribute to the decision-making. Teamwork is strongly monitored and facilitated: Through playful exercises and games the importance of knowledge transfer and information exchange is demonstrated at the beginning of the one semester class. The students learn that they are all important components of a common endeavor, *a community of practice*, and the success of the team depends equally on the performance of all its members.

Challenges of Teamwork

Teamwork is expected to be a form of learning that enhances mutual understanding and engages individuals in a process that is more productive than an individual project might produce. Studies show that "Generally speaking, team work affords the externalization of thought processes, the comparison of alternative perspective, social facilitation and socially monitored attentiveness to the task" (Salomon and Globerson, 1989, p.90).

However, practical experience shows that this is not always the case: there are social-psychological effects that debilitate team performance. Although it is commonly known by educators that teamwork possesses challenges and does not always function in an ideal way, the literature showing this is the case is scarce. Salomon and Globerson (1989) claim that:

> "A team is a social system, and as such it is a qualitatively different entity than a few individuals working alone side-by-side. Behaviors and cognitions in the group have two major characteristics: they become interdependent and this interdependence develops over time in a reciprocal manner. This developing interdependence implies that individuals' cognitive processes affect and become affected by the ones of the other team members… Such social cognitions both affect the social interaction and result from it." (pp.93-95.)

Like human behavior in general, the emerging team interdependencies are unpredictable and unforeseen to some extent. As its best, a team performance becomes more than the individuals alone could have

achieved. At its worst, teamwork can have detrimental, even disastrous effects on the learning, motivation, performance, and commitment of team members.

Salomon and Globerson (1989, p. 94-95) list some of the debilitating effects of teamwork:

1. The "Free Rider" Effect
   If a member of the team is particularly talented and hard-working, other members of the team can easily leave the task to the other, who would perform well in any case, thus taking the role of a "free rider". The "free rider" effect can also develop in a task that depends on the least able member, when the more able feels unmotivated. The effect is best avoided in additive tasks, where team performance equally depends on the contribution of all its members.

2. The "Sucker Effect"
   If a talented member of a group feels that his or her abilities are being exploited, he or she might become frustrated about being taken advantage of. As a result, both the talented and the exploitative members lose their motivation for the task at hand.

3. Status Differential Effects
   According to Dembo and McAuliffe (1987) those group members who are regarded to have a higher social status tend to dominate group activity and are more likely to receive and give help than members who are regarded to have a lower social status. They affect the group's final solution more than their fellow group members by gaining additional social influence within the group. In such conditions the team's optimal learning potential is not achieved.

4. "Ganging up on the Task"
   In some occasions the group starts to do its best to avoid the given task, and uses an excessive amount of energy to do the least possible amount of work to pass. If a member of the team is willing to put an extra amount of work into the task, the effort is welcomed, but no help will be provided by the others.

Other effects, like systematic segregation of task (where someone always does the typing, someone does the graphics, etc.) can occur if the team works together for a sufficiently long time. Competition between team members or teacher dependency can also have negative effects on group work.

In addition to listing the detrimental effects, Salomon and Globerson (1989) also present a number of factors that can help to avoid the negative effects mentioned above. Competition between groups (intergroup rather that intragroup) is one, while another is group dependence, where the task requires

complementary components from different groups. Task-related interdependencies among team members seem to be the best motivators for engaging in the task.

In general, it seems that the best results in teamwork are achieved when the given task is additive in nature. To engage all the members of the team, the collaboration needs to be designed in such a way that all members become indispensable, regardless of their social status, leadership abilities or individual talent. In a cross-disciplinary course setting, the members of the team possess expertise, skills or abilities that the others do not have. It affords a framework where all members can contribute and be part of common knowledge creation as equal team members. In order to make the contribution of all members valid and simultaneous, the task needs to be engaging and to allow the participation of all group members at all stages of the task.

Bridging Disciplines in Universities

How are we to form a new pedagogy that addresses the various needs and ways of teaching different contents and subjects? What means are needed to combine different didactic practices? What are the objectives and outcomes of this new pedagogy?

The planning of multidisciplinary university programs includes several levels and layers. The curriculum in a larger context defines how inclusive or exclusive the program is to be. Course planning defines the assignment level and the need for personal guidance and tutoring. These are important enablers of interaction, which are in fact the facilitators of learning. Students also become aware of their own expertise in interaction between students from different disciplines.

The challenge of interdisciplinary programs is to secure the growth, deepening and maturing of the students' own expertise in the discipline they consider their own. As much as communication and integrative collaboration between disciplines is needed, special know-how and penetrating expertise cannot be compromised either; enough adequate disciplinary education still needs to be provided. As important as the interdisciplinary interaction and holistic thinking is, separate fields of education are still needed in order to allow growth in deepened expertise. However, the relations of the disciplines need to be explored already in undergraduate education in order to allow the students to comprehend the "big picture" of our time, with all its nonlinear relations and evolving complex systems.

Common to the best contemporary practices of interdisciplinary, or *in-between-pedagogy*, is that they are not composed by merely combining existing curriculum components, rather that forming new combinations to start with a fresh approach (Hollmén and Rose, 2013). These new insights include teamwork skills, situated learning skills and experience, contextualized expertise, and an understanding of non-disciplinary knowledge creation. With these components, and ones yet to come, we can expect new measures for interdisciplinary studies to occur.

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