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TEACHING FOR 'INTERSYSTEMS ANALYSIS': HOW TO CREATE COMPANY-SPECIFIC ADAPTIONS OF A GENERIC FRAMEWORK FOR STRATEGIC SUSTAINABILITY PLANNING[1]

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Abstract: Strategic sustainable development is a key research and teaching area at Blekinge institute of technology (BTH). This area involves a generic Framework for strategic sustainable development (FSSD) that helps sustainability practitioners to structure tools and concepts according to their ability to support strategic sustainability planning at five levels: (i) system understanding, (ii) principled success definition, (iii) strategic guidelines, (iv) actions and (v) supporting tools. This structuring capability has been a key element of BTH sustainability courses for several years. Another related key ability of sustainability practitioners is to create 'intersystem' planning frameworks or to adapt the FSSD to a specific organization or context. In 2011 we replaced a tools and concept focused assignment with a new 'intersystems' assignment in the BTH course introduction to strategic sustainable development (MI2407). This paper intended to assess the internal consistency and logics behind the development of the new assignment. It also intended to follow up whether the students who went through the new assignment in 2011 could demonstrate the desired ability to create adapted planning frameworks. If possible this paper was also meant to check to what degree the MI2407 students would still be able to structure tools and concepts on the levels of the FSSD, now that they got less specific training on that skill. We found a clear internal consistency and constructive alignment in how the new intersystems assignment was put together. We also found indications that the students that went through the new assignment, in the MI2407 course in 2011, gained the intended ability to create adapted frameworks, while still gaining an ability to structure tools and concepts on the levels of the FSSD comparable to previous years. If these initial indicative learning outcomes are to be substantiated by further studies then the new intersystems assignment could also become a basis for new consultancy services that The Natural Step and other consultancies could pick up and spread to the business world. This would be much in line with our department's and BTH's general ambition to help sustainability practitioners to improve their strategic sustainability planning capabilities and to promote sustainable growth.

1. Introduction

This paper is based on the examination report from a University Teacher pedagogy course in 2011 at Blekinge Institute of Technology, karlskrona, Sweden. It is focused on pedagogy development for strategic sustainability planning in companies.

1.1 Purpose

This paper specifically intends to assess the internal consistency and logics behind the development of a new 'intersystems' assignment that is aimed to teach the ability to adapt a general framework for strategic sustainable development to a given organization or context. This paper also intends to follow up whether the students who went through a new intersystems assignment in the MI2407 course in 2011 could demonstrate a better ability than in 2010, when the traditional tools and concepts assignments was used, to adapt the general framework of strategic sustainability planning for a specific industry or organization. This paper should also check to what degree the MI2407 students would still be able to structure tools and concepts on the levels of the FSSD, now that they got less specific training on that skill.

1.2 Some pedagogical research on consistent and effective teaching

Before going deeper into the investigations we will look into some relevant pedagogical research.

Shifting focus from teaching to learning styles

In recent decades pedagogical research has increasingly shifted focus from the teachers activities to those of the students. Scholars like Biggs and Collis (1982) argue that knowledge is not something that in settings like a lecture can be transmitted directly from teachers to students. They rather see knowledge as something being created within students as they work on and relate to the data and methods covered in a course. This means that pedagogical research should probably focus less on lectures and more on how workshops and other activating learning

activities could promote student knowledge building and understanding. Biggs and Collis (1982) went on to suggest a theory that distinguishes between two main learning styles - surface learning and deep learning. Surface learners were described as focusing on passing exams and getting University degrees rather than, as deep learners, on aquiring and internalizing the knowledge taught in the education they take. Deep learners are almost in no need of teachers as they teach themselves. Biggs and Collis (1982) also developed a terminology to support their theory called the SOLO taxonomy which divides student understanding into five levels where the first three constitute surface learning and the last two deep learning (table 1).

Effective learning through proper variation

Pang and Marton (2005) emphasize in their variation theory that effective teaching requires that a suitable selection of facts are kept constant while others are varied. They argue that students cannot discover new knowledge if it is not contrasted against something that they already know. Most university courses are built up in this way, first defining knowledge prerequisites and then gradually introducing new concepts during the course. The trick, according to Pang and Marton, is in identifying what concepts to keep unchanged and what to add and in what pace this should be done.

Table 1. How the SOLO taxonomy describes increasing levels of student understanding (1-5).

Level	Understanding	Type of understanding	Abilities
5	Extended abstract (deep learning)	Contextual (generalize beyond information given)	To generalize To hypothesize To theorize
4	Relational (deep learning)	Relational (link aspects and draw conclusions)	To relate To compare To analyze
3	Multi structural (surface learning)	Serial (several relavant aspects–independently)	To classify To combine To enumerate
2	Uni structural (surface learning)	Nominal (one relevant aspect)	To identify To do a procedure To recite
1	Pre structural (surface learning)	None (No relevant aspect)	No understanding Irrelevant info Misses point

A special focus on troublesome knowledge and the treshold concepts

Perkins (1999) introduced the term troublesome knowledge to signify several types of knowledge that pose extra challenges to teach and learn. This includes tacit knowledge that the teacher is not aware of having, conceptually difficult and entangled knowledge and counterintutive knowledge. This means that extra teaching efforts are needed in these cases. This is particularly important if the trouble-

some knowledge also in Meyer's and Land's (2005) words are 'threshold concepts' that are key to insights and understanding in a knowledge field.

Consistent courses through constructive alignment

A problem that teachers often run into, especially with the above described surface learners, is that students focus on what will be put into the examination rather than what they are supposed to learn. Biggs (2003) has addressed this challenge by suggesting an approach for teaching and course design called constructive alignment. In short, this approach is focused on what the students do and that they through this should achieve the intended learning outcomes. The teacher should then design courses to make sure that learning objectives are reflected both in learning activities and examination, not leaving any shortcuts for them to pass the course without acquiring the intended learning outcomes. In practice constructive alignment is done in four major steps:

1 Defining the intended learning outcomes;
2 Choosing teaching/learning activities likely to lead to the intended learning outcomes;
3 Assessing students' actual learning outcomes to see how well they match what was intended;
4 Arriving at a final grade.

An integrated pedagogy for effective teaching

This short pedagogical research overview indicates that teachers could become especially effective if they first formulate what knowledge and practical abilites the students should gain from the course, then translates these into a sequence of troublesome pieces of knowledge and threshold concepts necessary to gain the desired learning. It also seems natural to follow up this with an aligned and suitable variation of learning activities and examination forms that promotes and assesses the desired learning. This has been nicely summarized by Bocur and Thorbek (2007) that claim that Biggs would define effective teaching as "teaching that forces the surface learner to behave like a deep learner". Now let us take a closer look at strategic sustainable development and some of its threshold concepts.

1.3 Strategic sustainable development

The Complex Sustainability and Tools Challenges

There is a growing scientific consensus that global society currently faces an increasing threat from human-induced climate change and other socio-ecological sustainability challenges (Meadows et al. 2004; Steffen et al. 2004; Millennium Ecosystem Assessment (MA) 2005; Stern 2006; Intergovernmental Panel on Climate Change 2007). This has called for many sustainability-related tools for analysis, decision support and monitoring like ecological footprinting (Rees and Wackernagel 1994); material intensity per service unit (MIPS) Factor 10 (Schmidt-Bleek 1997); and life-cycle assessment (LCA) (International Organization for Standardization (ISO) 2006). Without a unifying theory it is, however, unclear how these methods and tools can support strategic progress towards sustainability and how they relate to each other (Robèrt et al. 2002; Ny et al. 2006).

A Strategic planning framework for sustainability

To meet the sustainability and tools challenge a generic five level framework (5LF) for planning in complex systems was developed (Robèrt 2000). Applied for sustainability this is called the Framework for Strategic Sustainable Development (FSSD). It has been used for strategic sustainability planning in business (Nattrass 1999; Broman et al. 2000; Everard et al. 2000; Robèrt 2002a) and municipalities (James and Lahti 2004; Resort Municipality of Whistler (RMOW) 2007), and for creating cohesion between various sustainability tools and concepts (Holmberg et al. 1999; Robèrt et al. 2000; Robèrt et al. 2002; Korhonen 2004; MacDonald 2005; Byggeth and Hochschorner 2006; Ny et al. 2006). The 5LF and the FSSD operate at the following distinct and mutually interacting levels:

1 *The System*. Description of overall system behavior. In the case of sustainability planning how the planning topic (e.g. product or organization) operates within society and its surrounding ecosphere system. Using chess as an analogy, the systems level contains the rules of the game.
2 *Success*. A principled definition of a future state that the planning should result in. This does not prescribe certain actions but opens up to anything that can meet the success principles. In sustainability planning this corresponds to basic principles for sustainability and any other desired principles of success

for the planning topic. Similarly, chess has a few principles of checkmate that can be met in numerous ways by different constellations on the board.

3 *Strategic Guidelines*. Help for how to prioritize between alternative actions to gradually reach success, focusing on actions that are likely to move the planning topic towards success while being affordable and serving as logical and flexible platforms for future measures and investments. Chess players use similar principles to prioritize between alternative moves to take strategic steps towards checkmate.

4 *Actions*. Concrete measures that comply with the strategic guidelines for the process to reach a favorable outcome in the system. In sustainability planning this includes any concrete measure like implementing a recycling system or developing a new product that can run on renewable energy. In chess, every individual move is an action.

5 *Tools*. Methods and tools like sustainable development indicators, environmental management systems and life cycle assessments that are required to monitor the actions (level 4) to ensure they are chosen strategically (level 3) to achieve success (level 2) in the system (level 1). Tools for chess may include categorizations of typical and classical games, statistics, etc.

1.4 An assignment on structuring tools and concepts for strategic sustainable development

Once an organization carries out an initial strategic sustainability planning process, it is important to analyze possible supporting tools and concepts in more detail. Whatever tools are selected, they should be integrated with the FSSD to ensure that there is cohesion between the overall planning from the big picture and what practitioners monitor and measure in more detail. The FSSD and other tools should be seen as complementary and synergistic. Researchers from Blekinge institute of technology (BTH) in Karlskrona, Sweden, have been part of the FSSD development from its start 25 years ago. BTH is currently the leading academic site for development of the FSSD. The students in BTH's courses in strategic sustainable development are taught to use both the 5LF and the FSSD. In practice this means to be able to:

1 systematically analyze a tool or concept's inherent planning capabilities in relation to the levels of the generic five level planning framework (5LF).

2 to make good use of the same tools and concepts together with the Framework for strategic sustainable development (FSSD) when sustainability planning is in focus.

At BTH we have developed a student group work assignment called the 'tools and concepts assignment' to teach these abilities. In recent years this assignment has been given both in the introductory course (SL1301) at the master's program in Strategic Leadership towards Sustainability and in its campus-based short version (Introduction to Strategic Sustainable Development, MI2407).

1.5 New pedagogical approaches for the tools and concepts assignment

Even though the tools and concepts assignment has been refined with increasingly detailed and precise explanations it has previously been hard for some students, especially in the shorter and stand-alone MI2407 course, to grasp this assignment. Extra staff time has therefore been spent for complementing explanations. We have a continuous dialogue in the teaching team to deal with such issues and adjustments are made every year. There have also been many requests from students and researchers to find ways to more systematically teach how to make FSSD-based adapted planning frameworks for a given organization or topic. The pedagogy of how this should be explained and done is also something that we are studying together with practitioners in the industry (primarily The Natural Step consultants and their client companies). Students with good ability in adapting the general framework is already very much in demand in parts of the sustainability consultancy businesss. A word that has been increasingly used to describe the development of such adapted frameworks is – 'intersystems analysis'. Preparing for the school year of 2011 we decided to make a quite substantial change to the MI2407 course with a new tools and concepts assignment that should still somewhat cover the ability to structure tools and concepts on the levels of the FSSD but mainly shift the focus towards the ability to create adapted frameworks through 'intersystems analysis'. The lectures and reading materials focused on the ability to structure tools and concepts still remained untouched.

2. Method

As a basis for the reconstruction of the new assignment the key features of the previous assignment were first described in more detail (see section 3.1).

2.1 New assignment & examination reconstruction - constructive alignment

Constructive Alignment was used to review the assignment creation that had already taken place before this pedagogical study was conducted and to update its examination. In section 3.2 the following steps were followed (Biggs 2003):

1 Reviewing the relevance of the intended learning outcomes that should be met in a new way through the new assignment.
2 Reviewing the new assignment and other teaching/learning activities that are likely to help and encourage students to attain the intended learning outcomes.
3 Reviewing efforts taken to engage students in the new assignment and other teaching/learning activities.
4 Updating examination to assess students' learning outcomes.

2.2 Empirical follow up of the new assignment's effect on learning outcomes

The idea was here to search for improved MI2407 student abilities in line with the selected learning objective after going through the new assignment in 2011 compared to in 2010. Some other learning activities were still kept constant and the course SL1301 did not change at all between the years and could therefore potentially be used as a reference (table 2).

Table 2. Learning activity comparison for MI2407 and SL1301 courses between 2010 and 2011

Course	Learning activities 2010	Learning activities 2011
SL1301 (Sustainability focused students)	'Tools and concepts' assignment 'Tools and concepts' lecture 'Tools and Concepts' exam question	'Tools and concepts' assignment 'Tools and concepts' lecture 'Tools and Concepts' exam question
MI2407 (Students with mixed focus)	'Tools and concepts' assignment 'Tools and concepts' lecture 'Tools and Concepts' exam question	New 'Intersystems' assignment 'Tools and concepts' lecture 'Tools and Concepts' exam question New 'Intersystems' lecture

The various similarities and differences between the two courses called for several comparisons of learning outcomes within and between the two courses before and after the new assignment was introduced. To ensure valid results this was done in three steps:

Ruling out of potential learning outcome comparison biases

We need to first consider some basic facts and systematic similarities and differences, other than learning outcomes, between the student groups of MI2407 and SL1301 before and after the new assignment was introduced:

- ***Both courses have similar learning objectives but different length and depth.*** The elective course MI2407 gives 7,5 ECTS credits and can be seen as a short version of SL1301 (that gives 15 ECTS credits). Both courses are given in period 1 for about 8 weeks in the Autumn every year but SL1301 is more intense (full speed) while MI2407 is given at half speed and in parallel with other courses. This means that the SL1301 students get a more focused learning experience while the MI2407 students have to split their focus on several courses.
- ***SL1301 students are better prepared and motivated than MI2407 students.*** SL1301 is the first course in the popular master's programme Strategic Leadership towards Sustainability and the students taking this course are the best out of of a large pool of students that are particularly interested in its focus on strategic sustainable development. Some of the MI2407 students have chosen this course but others have to take it since it is part of their programme curriculum. In most cases the MI2407 students have other topics as their main focus and use this course to get familiar on how that topic relates to strategic sustainable development. This means that SL1301 students in most cases are both more interested in and better prepared for their course than the MI2407 students.
- ***SL1301 is more developed but MI2407 changed more in 2011.*** SL1301 is of course older than its off-spring MI2407 and has more teaching staff resources assigned to it since it is the key starting course of one of the most important master's programmes at BTH. SL1301 has therefore historically

gone through more intense development work than MI2407 but in 2011, did not go through any notable changes in the tools and concepts area that we study in this paper. Meanwhile, an extra effort was made to boost the performance of MI2407 by developing the new assignment and new complementing sessions.

- ***The two assignments are focused towards two different learning objectives.*** The tools and concepts assignment is about structuring methods and tools by placing them at the right level of the five level framework while the new intersystem assignment is about creating adapted five level planning frameworks for a given organization. Both student groups take the same tools and concepts lecture, though. A working hypothesis is therefore that even if we could find out that the MI2407 students have built an ability to properly place tools and concepts along the five levels it is more likely that they have received this from their tools and concepts lecture than from their new intersystem assignment.

2.3. Semi-structured teaching staff interviews to identify trends

It was desired to get a wider understanding and qualitative complement to the identified quantitative grade comparisons biases described above. This would include general impressions and trends in how the students' answers on exam questions and assignments indicated various levels of acquired understanding and practical abilities towards the desired learning outcomes. The author could provide some of this but could hardly be seen as neutral, having been instrumental in the initial build up of both courses and having been course responsible for MI2407 for most of the time since its first year, in particular the last three years. Even though a series of teaching assistants has made significant contributions to the course MI2407 the author has had a continuous interaction with the students and their learning outcomes. All major course curriculum decisions have passed through him. It was therefore desired to make semi-structured interviews with one or more people in the teaching staff that together have been active in both the studied courses, in particular to teach about the abilities to use the Framework for strategic sustainable development that this paper is focused upon.

The choice fell upon a teaching assistant that could meet the desired characteristics. He had helped the author to prepare the exam questions and also graded both

the new assignment and the final exam for MI2407 in 2011. He had also co-developed and worked with the previous assignment for a few years, both in MI2407 and SL1301 and lectured to the students about tools and concepts for strategic sustainable development.

A discussion took place around the following general questions (see section 3.3):

1. How do you see the new assignment relate to the previous one, in particular regarding what learning outcomes it may produce?
2. What comparisons do you think are relevant to make between assignments and student groups?
3. When grading exams and assignments, what, if any, general indications did you get that students had gained the desired learning outcomes?
4. Do you have suggestions for MI2407 course changes to improve the likelihood that students gain the desired learning outcomes?

Systematic learning outcome comparisons

Based on the above described interview and bias treatment a list of suitable (valid) learning outcome comparisons were identified and executed (see section 3.3.2). This built on assignment and exam grades from the two courses, before and after the new assignment was introduced.

3. Investigation and analysis

3.1 The tools and concepts assignment

This section summarizes the tools and concept assignment using excerpts from quite extensive overarching description documents. As mentioned above this assignment has for a few years been used in both the MI2407 and SL1301 courses.

Intended Learning outcomes

Both MI2407 and SL1301 have key learning objectives phrased around that the students should be able to both describe the FSSD and to apply it to assess the best use of various tools and concepts to promote sustainability. More specifically, SL1301 students should be able to (SL1301. 2011):

> *"Describe how various tools and concepts that are relevant for sustainable development relate to the FSSD."*

Similarly, MI2407 students should be able to (MI2407. 2011):

> *"Discuss the relevance of different concepts to strategic sustainable development."*
>
> *"Describe various tools and analyse how they can best be utilized for strategic sustainable development."*

In the tools and concepts assignment description (SL1301 and MI2407. 2010) this has been further specified:

> *"At the end of the completed assignment the learner should be able to:*
>
> 1. *Analyze a specific sustainability related tool or concept and determine for whom it was created and what it was created to do,*
> 2. *Determine whether the tool fulfils the goals that it was created to help users achieve,*
> 3. *Determine the role that the selected tool or concept can play in moving an organization or society towards sustainability (i.e. Determine how, when, in what context a tool can be best used to help practitioners move their organization or society towards sustainability), and*
> 4. *Identify how various tools and concepts relate to one another and can build on one another when planning for sustainability."*

Instructions to complete the task

The students are asked to form groups of 4-5 and to either select a tool or concept from a given list (e.g. Factor X, Forest Stewardship Council (FSC), Fair Trade, Genuine Progress Indicator (GPI), etc) or to suggest another topic for approval. The actual execution of the assignment is divided into three main parts that all should be given one chapter each in the students' written reports:

- ***Understanding the tool or concept using the generic five level framework.*** In this part the students should analyze their selected tool or concept to concisely describe its intended purpose. This is done by answering systematic questions at all five levels of the generic framework to see where it has

a role to fulfil. If they for example analyzed the concept 'Gross Domestic Product (GDP)' then they could say that GDP by definition measures the value of production of goods and services in a country in a certain year. Then this, contrary to how it is used in society today, cannot be a measure of success (at level 2 of the five level framework) since it is not stated why those goods or services should be produced. Rather, GDP measures a state of the system at level 1. It was also the initial intent when the GDP was first conceived in the US during world war II that it should help measure and maximize industrial production as the nation should quickly transform itself to war production. It was only later on that society let the maximization of this indicator also represent our long term goal.

- ***Assessment of the selected tool or concept using the FSSD.*** Here, the student should, based on the baseline assessment from part 1, determine how the selected tool or concept could help strategic sustainability planning by supporting each level of the FSSD. Going back to the GDP example, the student found out in part 1 that GDP in itself was a systems level indicator to be used to measure production, regardless of the planning goal. The student could now move on to suggest that GDP could mainly help at the systems level also of the FSSD, when sustainability is the planning goal.
- ***Advice to practitioners.*** The final part is to give advice on how to use the tool or concept in practice when planning strategically for sustainability, especially if there are complementing tools that would be needed for an effective result. Users of the GDP could here be advised to complement it with the value of environmental destruction caused by societal activities so that that it can reflect the net benefit of actions in a society that strives towards sustainability.

Evaluation

The students are evaluated by both peers and teachers. It is the final presentation and their written report that will be evaluated and they are in advance given the grading criteria that are directly derived from the above stated learning objectives.

3.2 New assignment & examination reconstruction

Reviewing intended learning outcomes

As mentioned in the introduction, the new intersystem assignment was an attempt to move beyond the above stated MI2407 course learning objective about being able to find the best use for various tools and concepts. Here, we also wanted the students to be able to make an adapted sustainability planning framework. This shifted the focus towards another MI2407 learning objective that states that students should be able to (MI2407. 2011):

> *"Identify new tools and determine their relevance for strategic sustainable development."*

In the new intersystem assignment description document (MI2407. 2011d) this was further specified:

> *"The assignment is designed to provide a basis for your future projects, either at school or at your job; and enable you to identify how decision-making frameworks in various organizations and situations can be best designed for moving society towards sustainability."*

It seems that these course and assignment objectives are aligned to a satisfactory *degree. As mentioned in the introduction, we also thought that activities training* the ability to make an adapted sustainability planning framework for a particular organization could be a new route to gain the ability to find good use of tools and concepts for sustainability.

Reviewing the new teaching/learning activities

The main added learning activity was the new intersystems assignment that consists of a group work with a written report and an oral presentation to the whole class. The students are urged to perform and describe three main tasks (MI2407. 2011d):

> *"**1. Current state of the decision-making framework**: Conduct a neutral analysis to gain a structured understanding of the decision-making framework as it is today. This means that you will examine*

how the decision-making framework relates to each level of the 5-Level Framework (5LF)."

*"**2. Ideal state of the decision-making framework**: Envision how the decision-making framework would look when aligned with a strategic sustainable development approach so that, while the decision- making framework continues to help decision makers achieve the designed goals, it is also contributing to move society towards sustainability. This means that you will structure the decision- making framework based in the five levels of the Framework for Strategic Sustainable Development (FSSD)."*

*"**3. Recommendations providing specific suggestions to your client**: Finally, backcasting from the ideal decision-making framework – based on the FSSD and based upon the four Sustainability Principles (SPs) – make specific recommendations to your client on how to bridge the presumed gaps between the ideal decision-making framework and the current decision-making framework. This will help your client better make decisions to move towards a sustainable society."*

A table was used to visualize and facilitate the completion of the three tasks (table 3):

Table 3. How the Intersystems assignment in three steps maps out and promotes an adapted framework

	5 LF - current state of the decision-making framework (to be filled in first)	**Specific recommendations to bridge the presumed gaps** (To be filled in last)	**FSSD based -ideal state for the decision-making framework (which integrates a SSD approach)** (To be filled in second)
System			
Success			

Strategic			
Actions			
Tools			

Reviewing teaching process efforts to engaging students in learning activities

In previous years, given that the Mi2407 students don't take sustainability as their major, we have had some challenges to engage some of them throughout the course and to make them see how the activities are aligned. We have therefore gradually improved the course overview document (MI2407. 2011b) to describe the connections between course learning activities and intended learning outcomes. Those connections are also reinforced when the activities takes place. In 2011 we added a linking lecture between course modules. As a complement to the new intersystems assignment we also added some extra lecture time with supporting explanations. The session was well attended and students seemed to like it. We will consider to increase such engagement efforts in coming years.

Updating Examination to assess students' learning outcomes

The course examination consists of a written final exam and written reports and presentations for two projects (one of which is the Intersystems assignment). Grades were given according to both a Swedish 3 to 5 scale and the ECTS F through A scale. We made predefined grading sheets for the presentations of projects 1 and 2, with several questions on both content and presentation style. With such a focus on project group work we also saw a need to work proactively against a 'free-rider' situation where some students may work significantly less, letting others bear the majority of the work. We therefore already in the course overview document added a peer-to-peer evaluation scheme for the group work. This evaluation was worth 15% of the grade for the intersystems project, where all students in the groups blindly graded each other according to a set of predefined questions. It is always sensitive for students to grade each other and that is why we made the individual grading blind and aggregated them to one peer grade per student. When we updated the final MI2407 exam of 2011 we made sure to cover both of the two intended learning outcomes behind the new intersystems assign-

ment. Question 5 covered the ability to find the best use of tools and concepts for sustainability (at the 2010 exam (MI2407. 2010) this topic was covered by question 12). Note that this question move from surface to deep understanding as it asks students to first remember the tools and concept as such and then how to apply them and finally to reflect on why they were best to use (MI2407. 2011c):

> *"Question 5. Tools and Concepts related to Sustainability (8 points total)*
>
> *DELL is a computer manufacturer that wants to improve their ability to develop more sustainable products. They want to increase their sales and brand value while moving towards sustainability. To do this, they want to adopt measures to demonstrate that their products perform well from a full sustainability perspective.*
>
> *For the scenario above, choose ONE of these tools listed below*
>
> *Factor X*
>
> *Natural Capitalism*
>
> *Ecological Footprint*
>
> *Life Cycle Assessment (LCA)*
>
> *Environmental Impact Assessment*
>
> *Zero Emissions*
>
> a. *List and give a brief description of the tool you have chosen (2 point)*
> b. *Describe how, specifically, you would use this tool to help DELL accomplish its goal (3 points)*
> c. *Why is the tool the best one for the need you have identified? (3 points)"*

Question 6 covered the ability to make adapted sustainability planning frameworks. This question is mainly focused on reflection so the students are not here examined on how to make adapted frameworks. Even though they are examined

on this ability in the assignment as such it could be good to add this in coming exams. This would potentially expose free riders that could get a high exam assignment grade without fully grasping the desired ability but hardly pass an individual exam question that asked for the same (MI2407. 2011c):

> *"Question 6. Final Assignment (3 points)*
>
> *In the final assignment you analyzed the decision-making framework of a particular organization or in a certain context. What would some key benefits be for any organization to adapt their decision-making framework to one informed by the FSSD? List and briefly describe ONE key benefit for each of the levels below:*
>
> *a. System (1 point)*
> *b. Success (1 point)*
> *c. Strategic (1 point)"*

3.3 Empirical follow up of the new assignment's effect on learning outcome

Semi-structured teaching staff interviews to identify trends

This is a summary of the outcome of the interview with a teaching assistant that is active in both the studied courses, in particular to teach about the abilities to use the Framework for strategic sustainable development that this paper is focused upon.

Q1. How do you see the new assignment relate to the previous one, in particular regarding what learning outcomes it may produce?

In the previous tools and concepts assignment the FSSD was used to identify where a given method, tool or concept could help on the 5 levels of the FSSD. This was mainly related to two MI2407 learning objectives:

> *"Discuss the relevance of different concepts to strategic sustainable development"*
>
> *"Describe various tools and analyse how they can best be utilized for strategic sustainable development."*

The new assignment, on the other hand, rather trains the student to make new adapted strategic planning frameworks for a particular organization or context. This is more related to the following MI2407 learning objective:

> *"Identify new tools and determine their relevance for strategic sustainable development."*

Q2. What validity concerns do you see when making learning outcome comparisons between the two assignments and the two student groups?

It may be possible that the 'new assignment' on top of training the ability to make adapted planning frameworks also helps the students to build an ability to identify the best use of various methods, tools and concepts. It will be hard to distinguish this effect, though, since both the MI2407 and the SL1301 students, apart from their respective assignments, also take the same supporting lecture on how to place tools and concepts on the five levels of the FSSD. For the case of the MI2407 the effect of the tools and concepts lecture may be limited, though, since, due to the workload in other courses, only about 15 students attended it.

In 2011 a comparable version of question 5 (the tools and concepts question) of the MI2407 exam was also given to the SL1301 students (question 6 of the SL1301 exam). This means that we should be able to compare their learning outcomes from their results on those respective questions. Unfortunately, in those questions, we never asked the students to place certain tools on the five levels. Rather, we asked generally about how tools and concepts may help to promote sustainability. This means that some MI2407 students may have had a particularly good understanding of a particular tool and when they then did well on this tools and concepts question it may have seemed that they knew more about the FSSD than they actually did. Something to think about when we make the questions for coming exams so that we test them on what is relevant in relation to the learning objectives. In question 6 of the MI2407 exam of 2011, in line with the learning objective behind the new assignment, we more directly asked the students to make adapted planning frameworks. This means that a good result on that question should be an indication that the students have gained the intended ability.

Even though it cannot be tested within these two courses, the students' demonstrated abilities in coming courses and thesis work will be a good indication of what they got out of these two respective introductory courses.

Q3. When grading exams and assignments, what, if any, general indications did you get that students had gained the desired learning outcomes?

It seems from the results of the new assignment that the MI2407 students, as intended, really understood the idea of adapted strategic planning frameworks. More specifically, they seemed to grasp the difference between (i) assessing the current state of an organization's strategic sustainability planning capability on the five levels, and (ii) suggesting a future ideal and adapted sustainability integrated planning framework for the same organization.

Q4. Do you have suggestions for MI2407 course changes to improve the likelihood that students gain the desired learning outcomes?

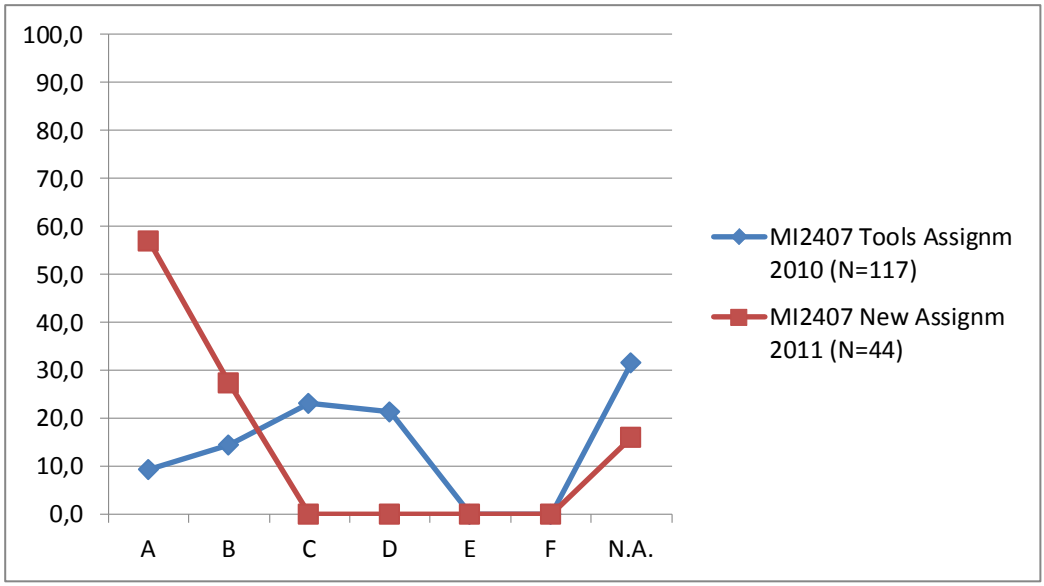
As indicated above, I suggest that we review course examination question (in particular exam question 5) to more closely measure progress towards the desired learning outcomes. I think the best way to measure the effect of the new assignment would be to split comparable students into two groups and let one of them take the tools and concepts assignment and one the new assignment. Then we could let the two students groups go through the same exercises (preferrably through comparable exam questions) to measure their learning outcomes in relation to the learning objectives.

Systematic learning outcome comparisons

With the basic similarities and differences between the student groups and assignments in mind, and to deal with validity concerns raised by the teaching assistant in the interview, the following systematic learning outcome comparisons were suggested and executed:

1. MI2407 student grades on the new assignment should be compared to the grades on the tools and concepts assignment of the MI2407 students from 2010. This could indicate if there is a direct performance improvement from the introduction of the new assignment. The resulting comparison clearly

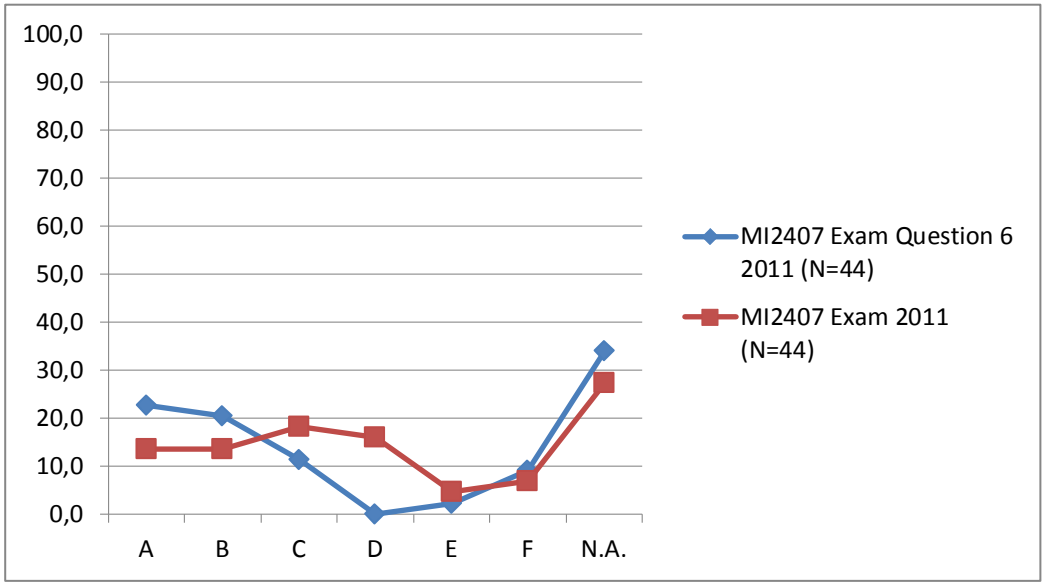
showed (figure 3.1) that both the share of students that completed the assignment and their grades improved significantly.



N = Total number of students, N.A. = Not Applicable (the student has not taken part in the assignment)

Figure 1. From 2010 to 2011, when the New Assignment replaced the Tools and Concepts Assignment, students from the course MI2407 both significantly decreased their tendency to not complete the assignment and increased their assignment grades.

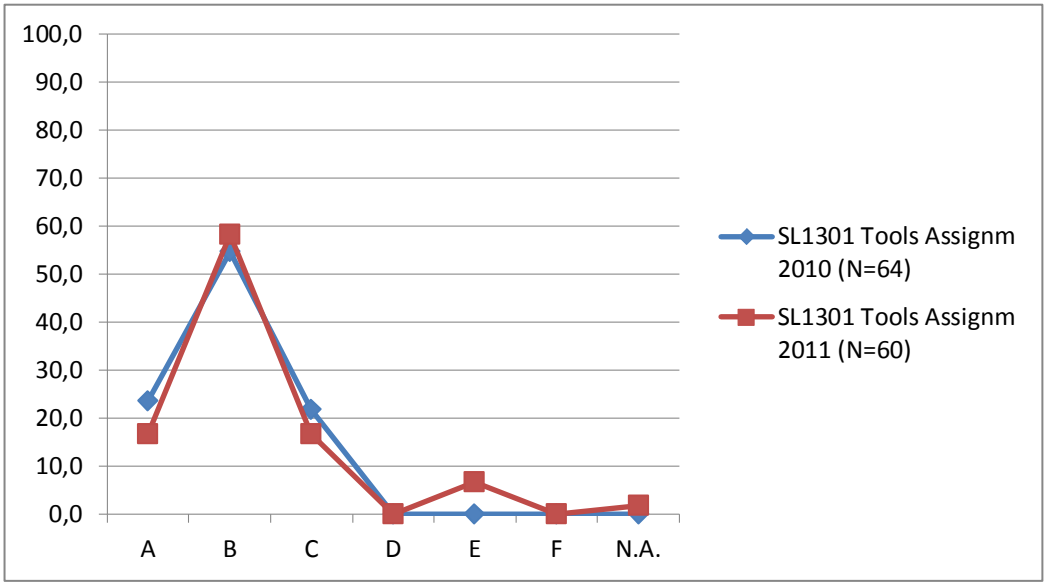
2. At the 2011 exams the MI2407 students, but not the SL1301 students, were tested on how to create adapted frameworks. This was asked for in question 6 of the MI2407 exam and it would therefore be interesting to compare if they did better or worse on that question than on the exam as a whole. If it could be established that they did better on this question then it would really indicate that the new assignment had had a learning outcome effect. This conclusion could be partly supported as the resulting comparison (figure 3.2) showed that the students more often had top grades on assignment 6 than on the exam as a whole. Apart from this the grades were comparable.



N = Total number of students, N.A. = Not Applicable (the student has not answered the exam question or attended the exam)

Figure 2. Students from the course MI2407 have a higher tendency for top grades, but otherwise similar results, on the intersystems assignment focused exam question 6 than on the whole exam.

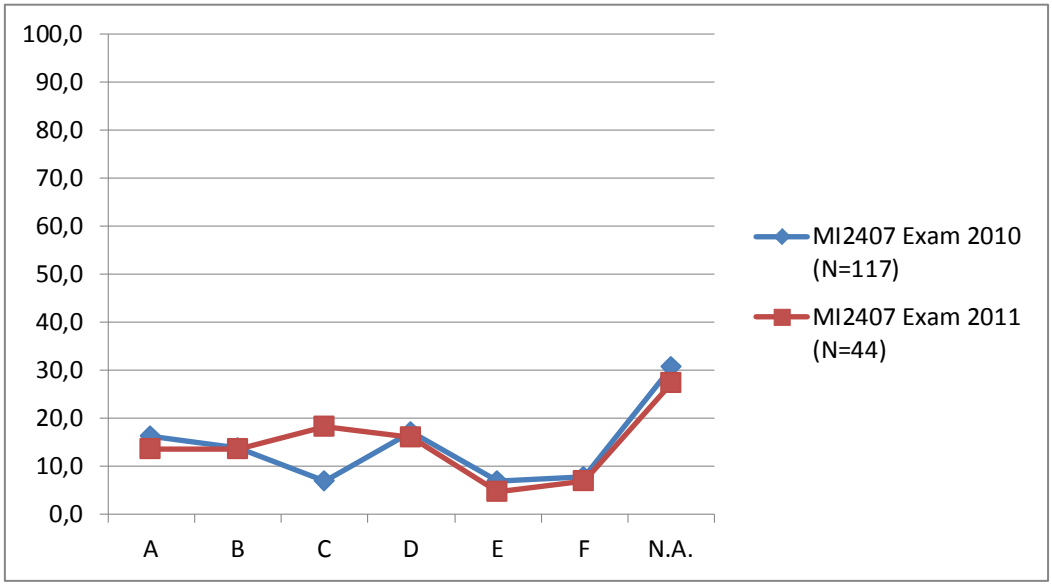
3. The SL1301 students had the same tools and concepts assignment both years and mostly the same related learning activities. This would imply that their assignment performance should not change notably in that period. It would be interesting to check this assumption by comparing assignment grades between the years. The resulting comparison (figure 3.3) clearly showed a high and unchanged performance of the students.



N = Total number of students, N.A. = Not Applicable (the student has not taken part in the assignment)

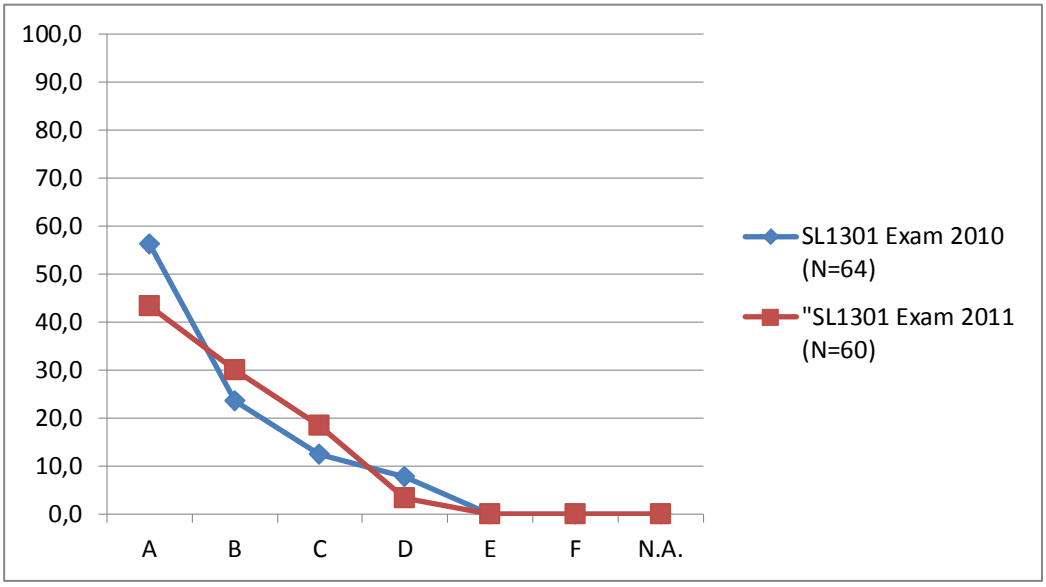
Figure 3 Students from the course SL1301 perform similarly well on the Tools and Concepts Assignment in both 2010 and in 2011.

4. If an improvement of assignment performance could be identified for students of either course this could still be related to that the performance of the 2011 student group is generally higher. Student exam and total course grades should therefore also be compared between the two years and related to the assignment performance. The resulting comparisons revealed that both MI2407 (figure 3.4) and SL1301 (figure 3.5) students had very similar exam performance between the years. The total course grades did however differ in that MI2407 students (figure 3.6) both improved their tendency to complete the course and improved their grades significantly while SL1301 students (figure 3.7) performed very similarly in the two years.



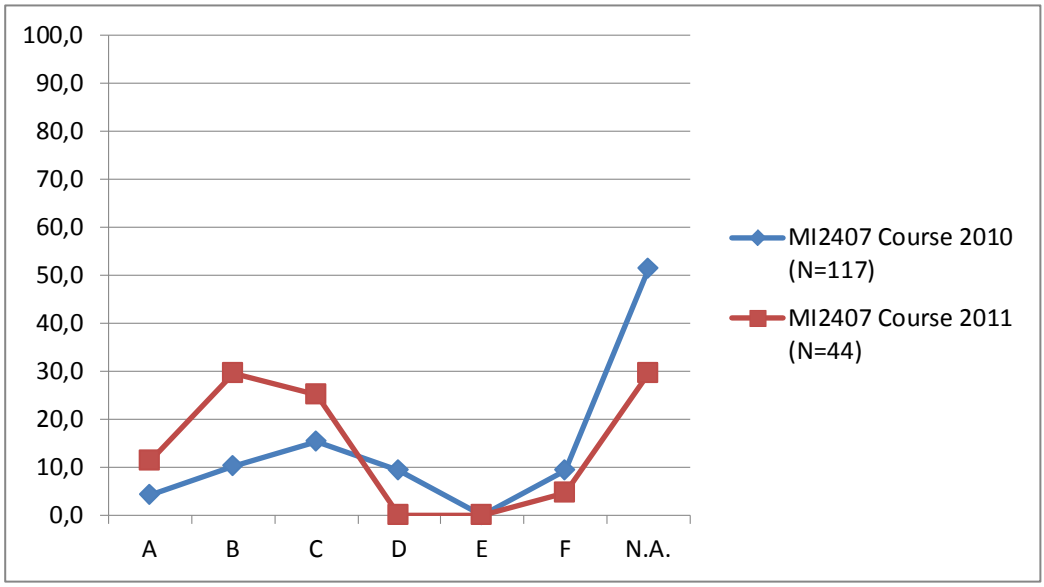
N = Total number of students, N.A. = Not Applicable (the student has not attended the exam)

Figure 4. Students from the course MI2407 have similar result on the exam in 2010 and 2011.



N = Total number of students, N.A. = Not Applicable (the student has not attended the exam)

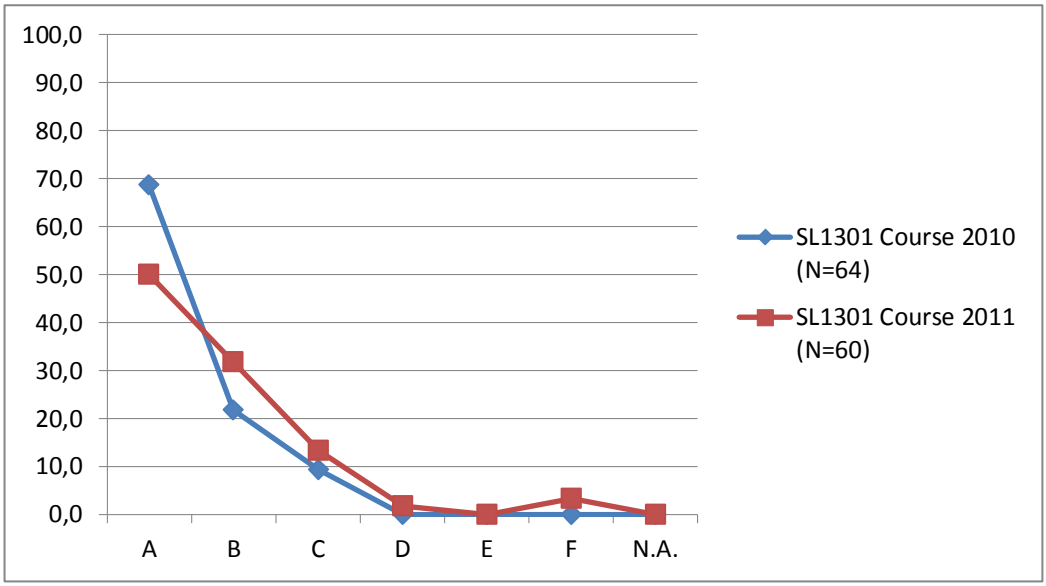
Figure 5. Students from the course SL1301 perform similarly well on the exam in both 2010 and in 2011.



N = Total number of students

N.A. = Not Applicable (the student has not completed the course)

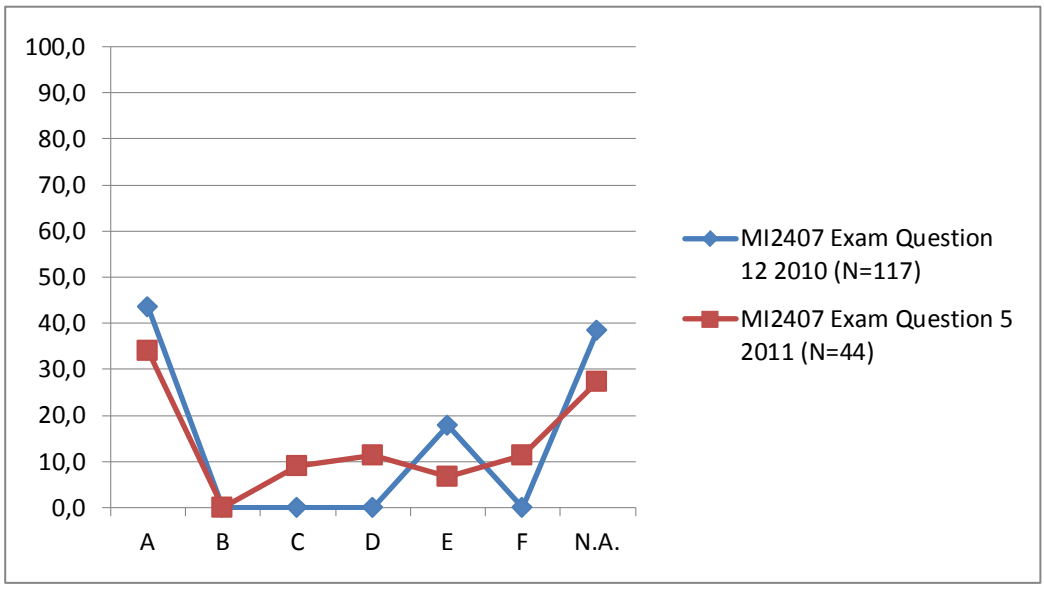
Figure 6. Students from the course MI2407 from 2010 to 2011 both significantly decrease their tendency to not complete the course and increase their total course grades.



N = Total number of students, N.A. = Not Applicable (the student has not completed the course)

Figure 7. Students from the course SL1301 perform similarly well on the whole course in both 2010 and in 2011.

5. Another thing to consider is that the focus of the two assignments are partly different. This means that an improved performance in the new assignment (that is focused on creating adapted planning frameworks) does not necessarily mean that they have become better at placing tools on the five levels of the FSSD (the focus of the tools and concepts assignment). We should therefore find complementing indicators of student performance towards the two focus areas. Suitable indicators for how well MI2407 students understand how tools can be of help towards sustainability then includes exam questions 12 from 2010 and 5 from 2011. The resulting comparison (figure 3.8) revealed that MI2407 students both have increased their tendency to answer the tools and concepts related questions and to receive a high grade.

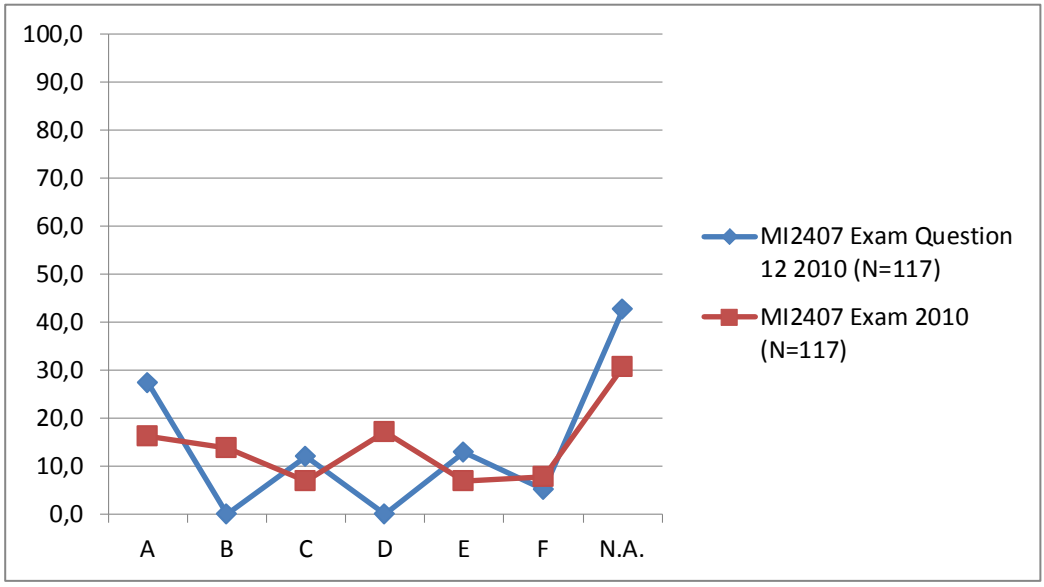


N = Total number of students

N.A. = Not Applicable (the student has not answered the exam question)

Figure 8. Students from the course MI2407 from 2010 to 2011 significantly decrease their tendency to skip the question about tools (question 12 and 5 respectively) and increase their question grades.

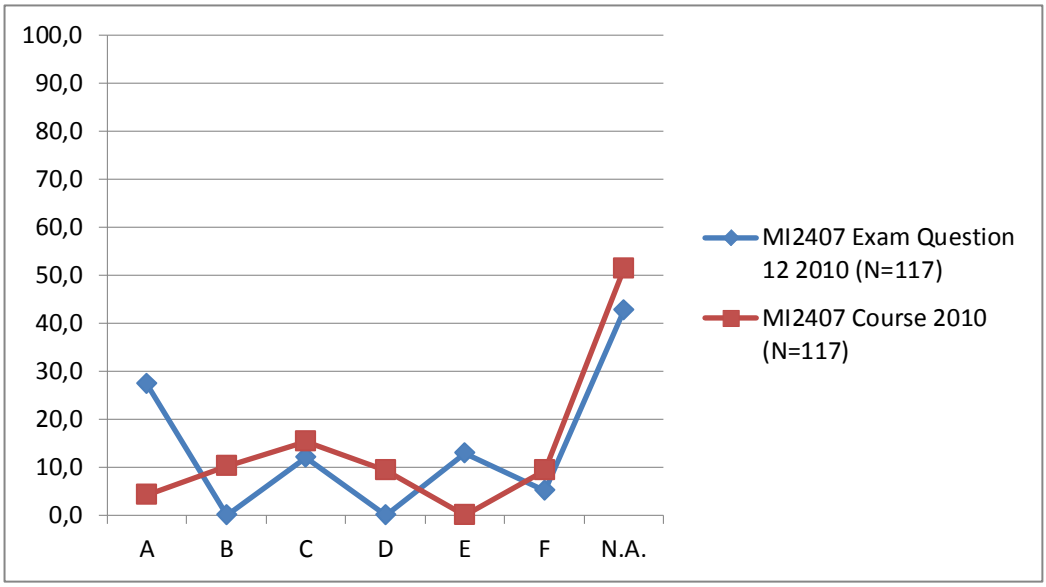
6. At this stage it would also be important to rule out that the improved performance of the MI2407 students on the tools and concepts questions (figure 3.8) was not just related to a general improvement in student performance between the two years. We should therefore compare their performance on the two questions in the two years to their respective grades on exams and whole courses. The comparisons (figures 3.9 to 3.12) gave no significant indications that the students performed better on the tools and concepts questions than on the exams and total courses. So, no general improvement of performance could be detected from 2010 to 2011. Still, they had a lower tendency to complete exam question 12 in 2010 than the exam as a whole.



N = Total number of students

N.A. = Not Applicable (the student has not attending the exam)

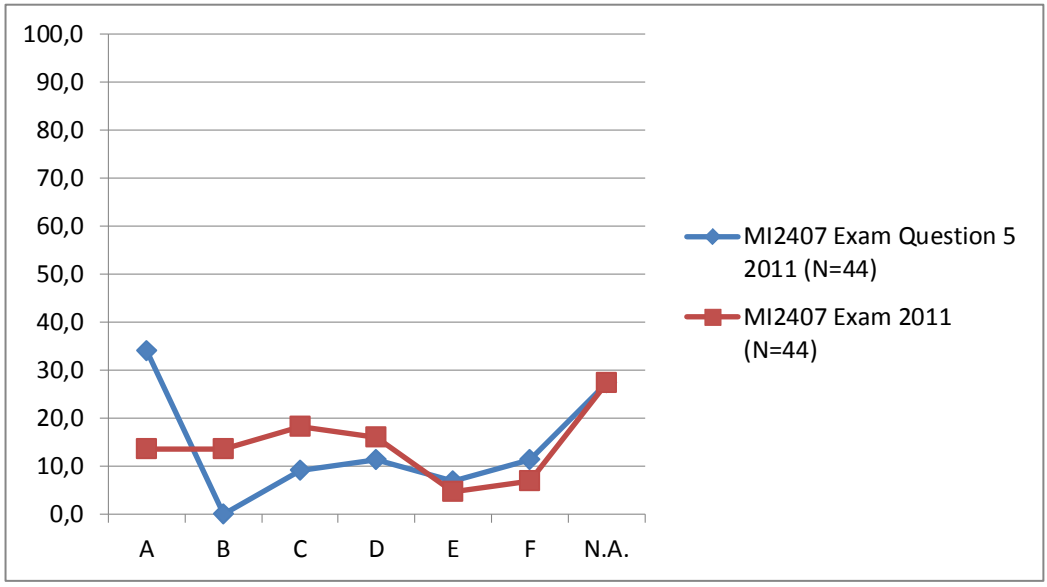
Figure 9. Students from the course MI2407 have in 2010 a higher tendency to complete exam question 12 (related to the tools and concepts assignment) and a slightly higher degree of top grades when compared to their performance on the whole exam.



N = Total number of students

N.A. = Not Applicable (the student has not answered the exam question/completed the course)

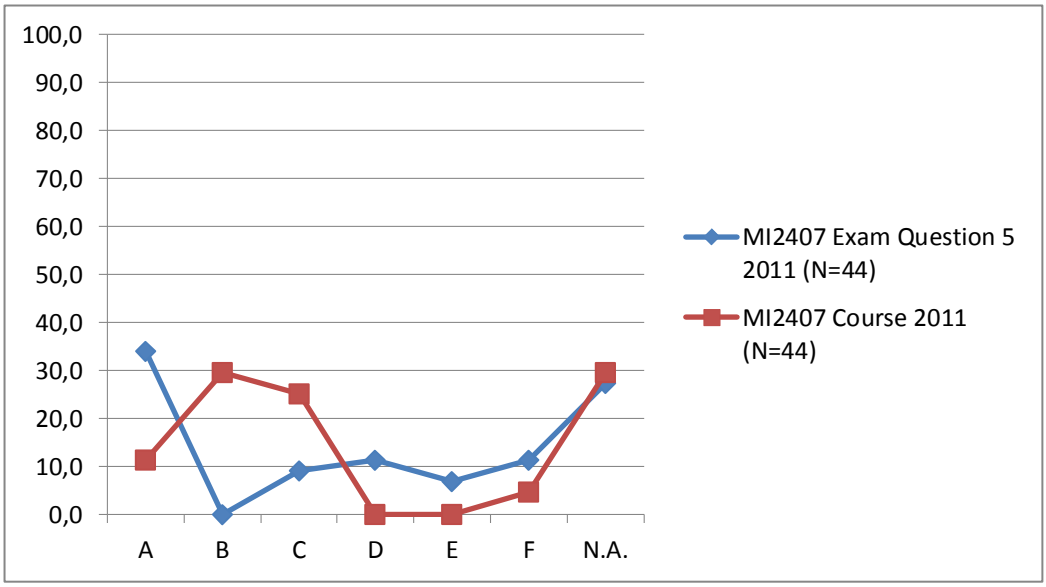
Figure 10. Students from the course MI2407 have in 2010 a similar result on exam question 12 (related to the tools and concepts assignment) as they have on the whole course.



N = Total number of students

N.A. = Not Applicable (the student has not answered the exam question/completed the course)

Figure 11. Students from the course MI2407 have in 2011 a higher tendency for top grades but in general similar result on exam question 5 (related to the tools and concepts assignment) than on the whole exam.



N = Total number of students

N.A. = Not Applicable (the student has not answered the exam question/completed the course)

Figure 12. Students from the course MI2407 have in 2011 a slightly higher tendency to get top grades and to fail exam question 5 than for the course as a whole but in general the results are similar.

4. Discussion

4.1 Main message

In response to the questions posed in the paper purpose, we have found a clear internal consistency and constructive alignment in how the new intersystems assignment was put together. We need further investigations to make substantial claims but we found indications that the students that went through the new assignment in the MI2407 course in 2011 gained the intended ability to create adapted frameworks, while still gaining an ability to structure tools and concepts on the levels of the FSSD comparable to previous years. All findings are further discussed below.

4.2 Supporting facts and critical assessment

The consistency and contructive alignment of the new assignment was supported by the comparisons made with the MI2407 course curriculum and its intended outcomes, teaching and exam questions. It could be added that the assignment came about in response to the realization that, to use Meyer's and Land's (2003) words, the intersystems was a threshold concept not sufficiently covered by learning activities. That is why we also added some complementing lectures to 'connect the dots' for the students. In line with the interviewed teaching assistant's suggestions, it would probably be a good idea to take another look at the assignment and the whole course to identify other potential threshold concepts and ideas for new complementing learning activities. Here we could probably also learn from how Pang and Marton (2005) tested new teaching approaches in an economics course. As a result we may also need to review learning objectives of the two courses, assignments and other examinations to optimally align with our pedagogical ambitions. Relating to general trends in pedagogical research (Biggs 2003), the examination seems to be particularly important to focus upon here since this seems to be the first thing that students focus upon in their studies.

The finding that the MI2407 had in fact gained the desired ability to make adapting frameworks was supported by both the general impressions that the grading teaching assistant expressed in the interview and by several statistical grade trends:

- The Mi2407 students got markedly better grades on the new assignment than they had received on the tools and concept assignment in previous years (figure 3.1). They also had better results on the intersystems question on the exam than on the exam as a whole (figure 3.2)
- Meanwhile, The SL1301 students, that had the same tools and concepts assignment both years and mostly the same related learning activities, showed a very similar grade performance during the two years (figure 3.3).
- It could partly be ruled out that the improved ability of MI2407 students on the intersystems assignment came from a general improvement in their capability. Both MI2407 (figure 3.4) and SL1301 (figure 3.5) students had very similar exam performance between the years. The MI2407 students did however improve their total course grades compared to the previous year (figure 3.6) while SL1301 had similarly high grades (figure 3.7)

The finding that the MI2407 students in 2011 still gained ability to structure tools on the levels of the FSSD compared to previous years was supported by both the grading teaching assistant's impressions and by that:

- They both increased their tendency to answer the tools and concepts related questions and to receive a high grade (figure 3.8).
- It could be ruled out that their improved performance on the tools and concepts questions was not just related to a general improvement in student performance between the two years (figures 3.9-3.12).

4.3 Further work and wider implications of study

All in all the new assignment likely worked as intended but the comparisonS should be extended for longer time periods to make it possible to make more solid conclusions towards that claim. There are also some added evaluations that could increase the validity of this research. We could for example also compare the students' group work reviews and individual exam scores in both courses. This is to possibly detect if there are only certain individuals who have good results on both parts of the examination and therefore may have done a disproportionately large share of the work. This could mean that other students in the groups may have not understood but yet been able to pass as 'free riders'. It would also, in line with the teaching assistant's suggestions, be interesting to try the new assignment on the more advanced SL1301 students. Perhaps this could improve their learning experience even further. In any case we should probably follow up with more interviews and tailor-made course evaluation questionnaires to get a better picture of the perceived knowledge gained by the students themselves. Finally, if the intersystems assignment eventually will become established as a good way to teach students how to adapt frameworks, then it could also likely form the basis for new consultancy services that The Natural Step and other strategic sustainable development consultants in the field could pick up and spread to the business world. This would be much in line with our department's and BTH's general ambition to help sustainability practitioners to improve their strategic sustainability planning capabilities and to promote sustainable growth.

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