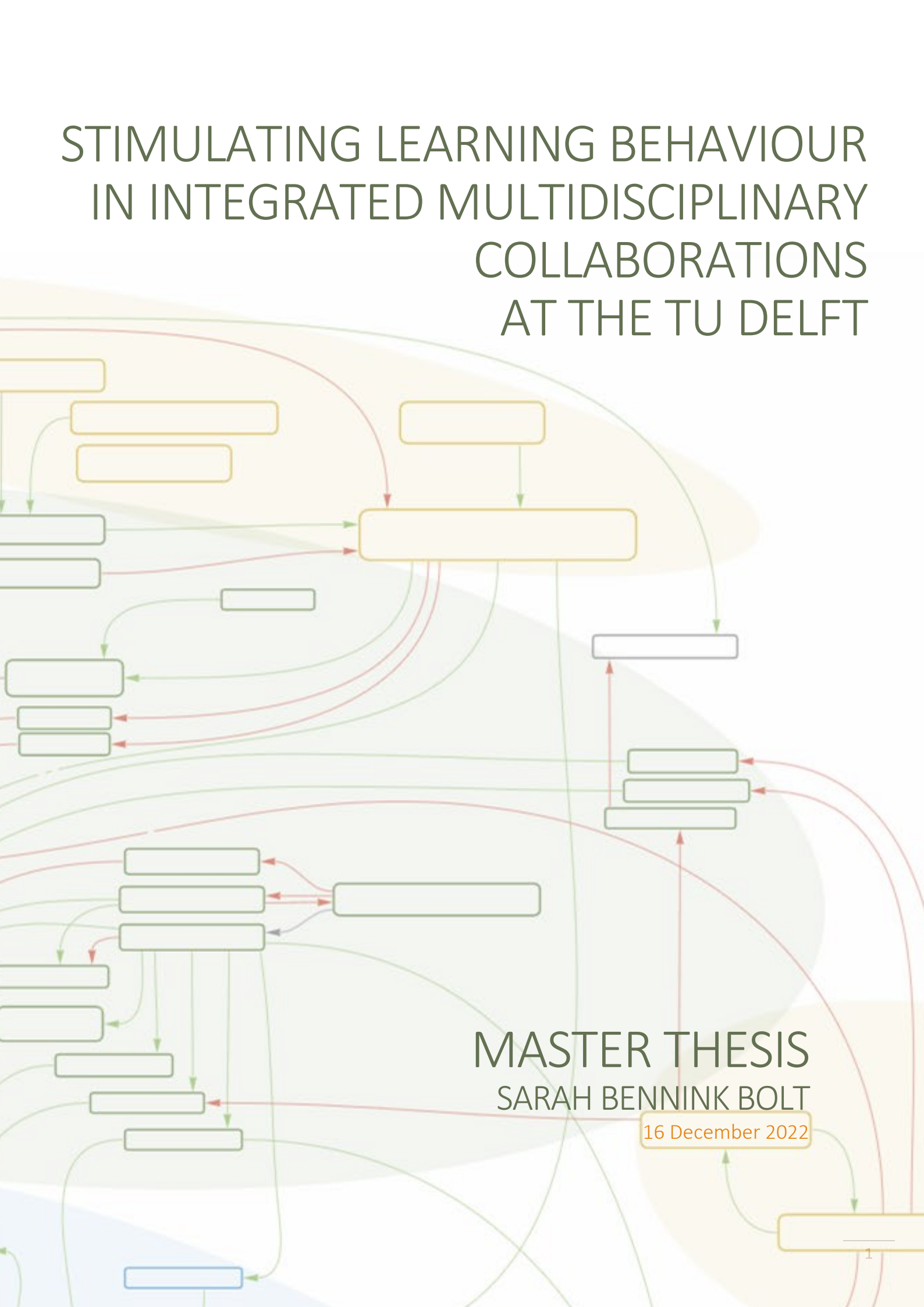
STIMULATING LEARNING BEHAVIOUR IN INTEGRATED MULTIDISCIPLINARY COLLABORATIONS AT THE TU DELFT



MASTER THESIS

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Stimulating learning behaviour in integrated multidisciplinary collaborations at the TU Delft

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SUMMARY

A shift in academia is taking place, from individual excellence towards more collaboration. Where autonomy and individuality are highly valued by scientists and the systems in which they operate, a push towards more collaboration in the scientific field in the Netherlands is inevitable. Scientific issues are becoming increasingly complex and demand a wide range of expertise and methodology in order to be solved. This necessitates not only collaboration, it requires far-reaching integration and leads to inevitable interdependency within the collaboration. To be successful, one needs to combine the knowledge available within multiple disciplines to create a solution together. In these collaborations, team learning behaviour becomes a necessary collaborative effort in order to work together effectively.

In this research, team learning behaviour in multidisciplinary academic teams at the TU Delft is investigated. It focusses on integrated multidisciplinary collaborations, which include inter- or transdisciplinary collaborations and everything in between. The goal of this research is to come up with an idea that could help stimulate team learning behaviour.

Through a non-systematic literature review, an extensive overview of factors that have an influence on team learning behaviour and their underlying relations is made. The factors are categorised as learning boosters and learning drainers. A diagram is used to show the complexity and interconnectedness of the influence factors on team learning behaviour. From this overview, a section was chosen to focus on, the antecedent factors. This is the section with which the TU Delft could most effectively influence the team learning behaviour of its academic integrated multidisciplinary collaborations.

Through semi-structured interviews, issues were identified with the current team learning behaviour within these collaborations. These issues turned out to be spread out over three different levels. Some issues can be addressed within *collaborations*. Some issues are broader than a collaboration and can only be solvable within the *organisation*, in the TU Delft. A few issues present themself more in the whole *academic field.* These issues might not be solvable by the TU Delft, but they might be able to contribute.

Three main themes were identified to be in the way of the collaborative effort of learning behaviour:

- **Low prioritisation of collaborative work due to the pull to individualistic work**. This issue presented itself within the *collaboration*, the *organisation,* and the *academic field*.
- **Non-efficient collaboration activities**. Within the *collaboration*, this is partly due to implicit communication. This results in scientists often having to spend their personal time on collaboration efforts, which could be tackled on the *organisation* level.
- **Few integrated multidisciplinary collaboration opportunities**. In the *organisation* this is mainly visible in job and education opportunities given by inherently monodisciplinary faculties. In the wider *academic field,* this shows itself in fewer publication opportunities.

As the result of this research, a toolset has been developed to help stimulate learning behaviour. The tools facilitates a session with people who can influence either a *collaboration,* the *organisation* or the *academic field* to find solutions to issues raised. The output of this session are concrete goals and action points to carry out.

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1. INTRODUCTION

1.1 Context

As scientific knowledge advances, scientists become more specialised in specific topics. Questions and issues that these scientists are tackling currently are becoming increasingly complex (Jeffrey, 2003). Solutions are needed that are so multifaceted, they call for a wide range of expertise and methodology to be solved. This necessitates not only specialisation, but also interdependence. Therefore, a push towards more collaboration arises. For academics, this is not a natural shift. In academia, autonomy and individuality are highly valued. Their success is measured by the outcome of a competitive battle with their peers for funding and further academic employment. Many scientists do try and collaborate, but their pull towards individual excellence - which is often more rewarded and appreciated - typically causes these efforts to disappear to the background or become a side business (Fernández, 2022). This could stand in the way of scientific progress.

In academia in the Netherlands, the disbalance between individual excellence and collaborative success is becoming more apparent. On the one hand, scientists are trained to become independent early on in their scientific careers, focussing on publishing papers and scoring a high H index. On the other hand, we see external pressure to shift towards more integrated and interdependent collaborations in order to further scientific progress. Governments push towards democratisation of science (van Zon, 2022) and make funding more accessible to broadly integrated (inter)national collaborations (Kurtulmus, 2021). This push can also be seen in position papers by NWO and VSNU (VSNU et al., 2019) in which the balance between individual excellence and collaborative success is better safeguarded. The TU Delft took this position paper as a starting point to set up the Recognition and Rewards perspective of the TU Delft (TU Delft, 2020).

Setting up this research

In multiple collaborations consisting of different scientific disciplines within the Leiden-Delft-Erasmus (LDE) alliance, it is found that these types of collaborations are difficult to set up. The Recognition and Rewards department therefore wants to look into possibilities for the TU Delft to stimulate teamwork and create high-performing teams in transdisciplinary collaborations, as part of one of the Recognition and Rewards goals of the TU Delft: “Stimulate teamwork and creating high-performing teams” (TU Delft, 2020). The goal of this thesis is to come up with a design that can improve transdisciplinary academic collaborations. I will specify this goal in the next section.

Transdisciplinary collaborations and learning behaviour

Transdisciplinary collaboration is seen as the most integrated form of collaborations where multiple disciplines work together. In this type of collaborations, people have to understand concepts and methods from another discipline. While collaborating, they develop intertwined knowledge. This is said to lead to more creative innovation, which is necessary for wicked problems (Rittel & Webber, 1973). At the same time, it also causes uncertainty because scientists are moving into unknown territory. Rosenfield (1992) explains that: “*Each team member needs to become sufficiently familiar with the concepts and approaches of his and her colleagues, as to blur the disciplinary bounds and enable the team to focus on the problem as part of broader phenomena: as this happens, discipline authorization fades in importance, and the problem and its context guide an appropriately broader and deeper analysis.”*. This means that team members let go of their own disciplines and accompanying prejudices to not let that get in the way of focussing on the issue at hand. Almost creating a new hybrid discipline in the process. This implies a need

for understanding of various disciplines. To get this understanding, team members need to teach and learn from each other in order to collaborate successfully. Team learning behaviour can therefore be said to be an important factor in integrated multidisciplinary teams, let alone in in transdisciplinary teams, to generate new knowledge (Park, 2010).

Team learning behaviour

Team learning behaviour is a collaborative effort which is used to acquire and process knowledge in order to adapt and improve. It is made up of different actions that are often described as an iterative process (Edmondson, 1999). There are many different definitions of team learning behaviour. In this thesis, it will be examined from a practical viewpoint to evaluate how it is done in collaborations. Therefore, this definition of Edmondson is chosen.

Team learning behaviour in transdisciplinary collaborations is thus chosen as a focus in this research.

1.2 Research questions

1. What factors can be derived from literature that have an influence on team learning behaviour in transdisciplinary collaborations?
2. How do individual scholars working in academic transdisciplinary collaborations at the TU Delft perceive their current team learning behaviour?
3. What do individual scholars working in academic transdisciplinary collaborations at the TU Delft think about getting help or stimulation from the university for team learning behaviour?
4. How can the TU Delft stimulate team learning behaviour in their academic transdisciplinary collaborations?

How these research questions relate to one another can be found below (Figure 1).

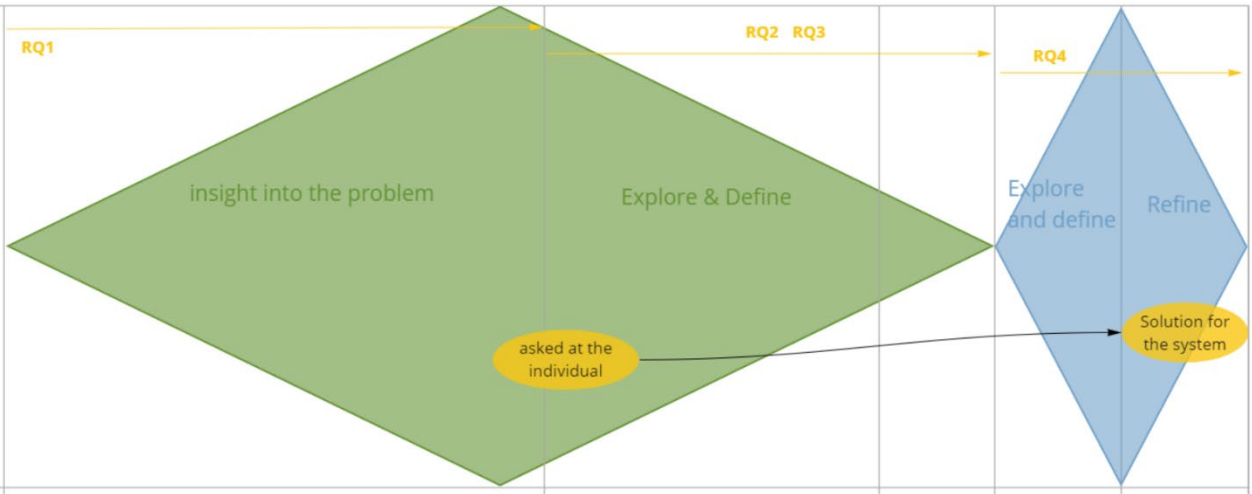
Figure 1: How the research questions relate to each other.

1.3 Approach and method of this thesis

The general approach for this thesis is based on the double diamond approach proposed by Banathy (1996) . This is to diverge and converge consecutively to get to the final solution. This is chosen because an exploration needs to be done first in order to get a general understanding of what can be designed for.

Literature about team learning behaviour is often not specifically about academic collaborations. No research is done at collaborations at the TU Delft on team learning behaviour in academic collaborations. Therefore, the literature about team learning behaviour studied for this thesis focuses predominantly on general teams. The applicability of these results on academia will be validated in the academic landscape of the TU Delft.

An overview of the double diamond approach for this thesis can be found in Figure 2, the width of the columns roughly corresponds to how much time that part takes, relative to the entire research. In the next section, I will elaborate on this overview.



Methods	Literature review	Semi-structured interviews & Dataprocessing	Problem identification	Design methods	evaluation and final concept
Deliverables	theoretical framework	results	problem statement	design requirements	a concept
Chapter	1 & 2	3 & 4	5	6	6

Figure 2: Overview of the double diamond approach for this thesis.

Methods used in these diamonds

I will use interpretive methods to get a better understanding of what ways team learning behaviour takes place.

Research phase - 1st diamond

In the diverging research stage, I start by defining certain concepts such a learning behaviour and transdisciplinarity. Then I read previous theses of the Communication Design for Innovation (CDI) department. After that, I preform a non-systematic literature review. These results are put together with the adaptation of existing Input-Process-Output (IPO) models of processes. An IPO model comes from system analysis and describes the basis structure of a process (Figure 3).

Figure 3: Basics of an IPO model.

After that, I investigate in what way this outcome is representative for academics in collaborations with multiple disciplines at the TU Delft. I will determine what the participants think about team learning behaviour in their collaborations by doing semi-structured interviews. This is done to get the individual perspective of academics about their collective team learning behaviour. These qualitative results are then analysed with code-occurrence and cross tabulation analysis, done in ATLAS.ti, to find an area where support can be offered. This is called the problem identification and ends in a problem statement, with which the design phase will be started.

Design phase- 2nd diamond

The next step is to explore the boundaries for the final concept.

In the design phase, concept options will be explored to solve the issues raised in this research. One of the concepts will be tested to check if the requirements of the concept are met and to collect feedback on where to improve.

A methodology per chapter can be found at the beginning of the corresponding chapter.

2. LITERATURE REVIEW

2.1 Methodology

This literature study is focussed on answering sub-question 1: What does literature say is important for learning behaviour in collaborations with multiple disciplines? For this, a non-systematic literature review was conducted starting with search terms (Figure 4) to enter into search engines. More specifically, to find a focus a broad explorative review of scientific articles, previous theses, blog posts and books were searched The keywords were sometimes combined to find literature.

The search was predominantly done on Google Scholar, and often a second search was performed if the articles were also on Web of Science, ResearchGate, PubMed Central or other more reliable search engines. The articles were, if necessary, accessed using TU Delft licences. For literature older than 2000, another search was executed too check if the information was still accurate. All literature was gathered in Mendeley.

Figure 4: Search terms used to find literature.

After this, literature found was used to snowball further to interesting sources and papers. In order to widen the possibilities, this was not specifically tailored to academic collaboration teams. This is acceptable, because the literature will be checked in academic collaborations to see if it is representative.

After this search, the choice was made to focus on team learning behaviour. A first draft of factors that work on team learning behaviour was made based on three sources: the thesis of Thijs Elzer (2021) in which boosters and drainers for team learning behaviour were listed, the model of work-team-learning by Edmondson (1999), and learning factors researched in Kim et al. (2020). The sources used in these researches were then used to snowball further for more factors or more relationships between found factors.

2.2 Exploring concepts

To start the literary review, first the main concepts 'multi-, inter- and transdisciplinarity' and 'team learning behaviour' are looked into and defined.

Multi-, inter- and transdisciplinarity

It was noticed that transdisciplinarity is a concept that means different things to different people. This is partly because, while collaborations consisting of multiple disciplines have been around for a long time, concepts like inter- or transdisciplinarity are said to be rooted in the late twentieth century (Frank, 1988). These new terms were made to distinguish between existing variances in multidisciplinarity and to describe new types of multidisciplinarity. For example, multidisciplinary collaborations that have started to work more and more integrated. When looking at literature, different nuances are found in what distinguishes multi-, inter- or transdisciplinarity and many different versions of images like Figure 5 can be found.

A difference in terms found in literature is the involvement of non-academic participants in transdisciplinary collaborations. As seen in Figure 6, Tress et al. (2005) claims this is what differentiates inter- from transdisciplinary. On the other hand Rosenfield (1992) states a difference between the two is the level of integration.

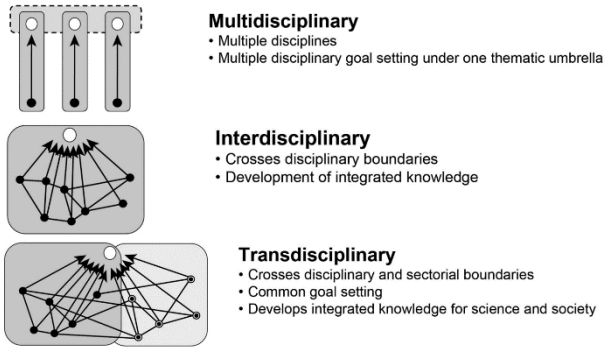


Figure 5: Difference between multi-, inter- and transdisciplinarity. (Tress et al., 2005)

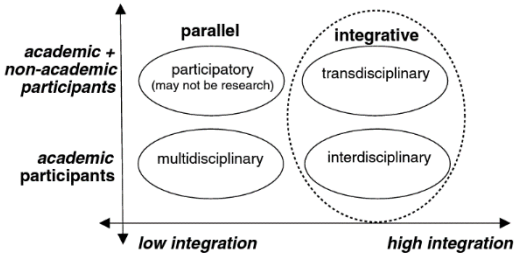


Figure 6: stakeholder involvement in multi-, inter- and transdisciplinarity. (Tress et al., 2005)

For this thesis, to avoid confusion, the terms inter- and transdisciplinarity are not used any further. A new figure will be constructed (Figure 7) based on Rosenfield (1992) theories and on what Jensenius claims what seems to be true for many at this moment: *"I am still not entirely sure that I understand the difference between interdisciplinary and transdisciplinary, … the latter is just one more step towards full integration."* (Jensenius, 2012). This is used to rename these types of collaborations *multidisciplinary integrated collaborations*. In very integrated collaborations people have overlap between content and work. They are dependent of each other to further their work and have to understand concepts and methods from another discipline. With that, they develop intertwined knowledge. *Multidisciplinary* is used here as an objective statement, that a collaboration consists of multiple disciplines. Next to that, they have the possibility to be on a spectrum from not integrated towards fully integrated. This also allows collaborations to be somewhere along the spectrum, not necessarily boxed in one of three concepts.

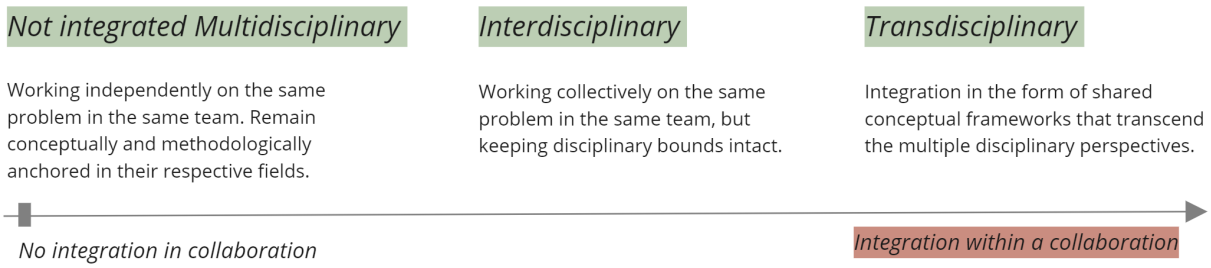


Figure 7: Putting disciplinarity's on a spectrum of integration in collaboration, based on terms by Rosenfield (1992)

A transdisciplinary collaboration is seen as the most integrated form and is thus on the most right of this spectrum.

Team learning behaviour

A deep dive was done on team learning behaviour. What this concept means in theory and what it looks like in practice.

In literature many different definitions of learning and team learning behaviour can be found. In this thesis a definition was used for team learning behaviour to specify the process instead of an

outcome. This process of learning is defined by both Edmondson (1999) and Argote, Gruenfeld, and Naquin (1999) as an activity in which individuals within a group acquire, share, and combine knowledge (Edmondson, 1999; Argote, Gruenfeld, and Naquin, 1999).

Because of its iterative character, learning behaviour is more often than not described as a cycle. Gibson & Vermeulen (2003) have a more practical explanation of what learning behaviour looks like. They gathered many perspectives including (Argyris and Schón, 1978; Jellinek, 1979; Kolb 1984; Henderson and Deighton, 1988; Zenger and Lawrence, 1989; March, 1991; Edmondson, 1999; Cohendet and Steinmueller, 2000; Gibson, 2001) , to set up their 'Learning Cycle', consisting of three elements (Figure 8). They add: *"A team will exhibit optimal learning only if all three elements of the learning cycle - experimentation, reflective communication and codification-are present."* (Gibson & Vermeulen, 2003).

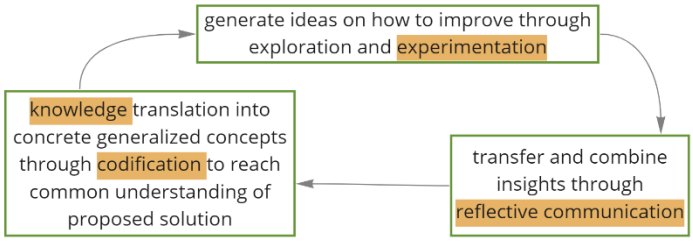


Figure 8: The Learning Cycle by Gibson & Vermeulen, 2003.

To make team learning behaviour as understandable as possible for interview participants, more practical definitions with examples were found to help them understand, recognize, and reflect on their own team learning behaviour. These concrete actions, that would be seen in such team learning behaviour, are taken from Edmondson (1999). In a random order, these activities consist of asking questions, asking for feedback, experimenting, reflecting on outcomes, and discussing errors or unexpected results. These activities are executed with the goal to identify knowledge gaps and fill these in.

Figure 9: Set of activities recognizable for team learning behaviour by Amy Edmondson (1999)

Edmondson also underlines the importance of discussing assumptions and differences of opinion openly in the group. That way, team learning behaviour takes place instead of individual learning behaviour (Edmondson, 1999).

2.3 Looking back at previous CDI theses

Previous student theses from the Communication Design for Innovation (CDI) department were reviewed to see what could be built upon. There were two theses that stood out and were used to further the literature review: the master thesis of Marre Niessen (2020) and the master thesis of Thijs Elzer (2021)I will discuss them in that order.

The Dynamic Collaboration Model (DCM)

Marre Niessen describes the Dynamic Collaboration Model (DCM) set up by Hanneke Stenfert and Éva Kalmár, of the CDI department of the TU Delft (Kalmár & Stenfert, 2020). This model is based on the widely accepted input-process-output (IPO) framework of systems analysis to describe processes (Hackman, 1987). The DCM model could be used to build upon, to research the process of team learning behaviour and everything that has an effect on it. It studies collaborative efforts as an iterative cycle and is currently being tested as a general model in different case-studies (Figure 10) (Kalmár & Stenfert, 2020).

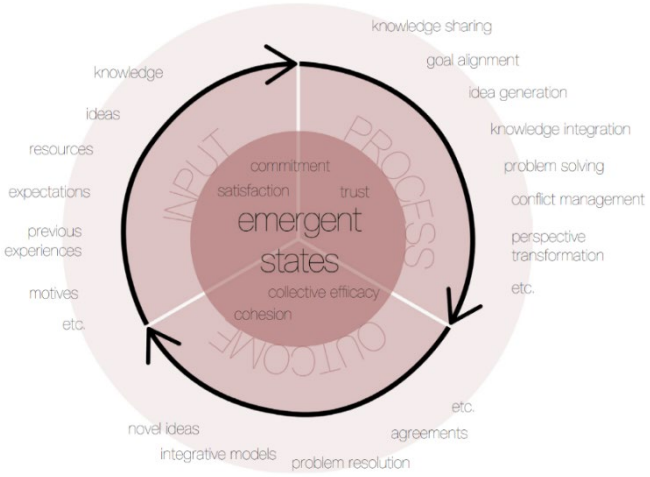


Figure 10: A dynamic collaboration model: capturing a dynamic perspective on the development of collaborative capability within teams (Kalmar & Stenfert, 2020)

This DCM consists of different segments. The Input is taken into the collaborative effort. The Process is the actual action of the collaborative effort in which inputs are transformed into outcomes. The Outcome consists of what is taken away from the collaborative effort that can possibly be used as input for a new collaborative effort. This makes it an iterative model. The DCM is specifically meant for measuring collaborative efforts during collaborations and not afterwards.

The emergent states in the middle are an interplay between the three segments of the DCM and varies as a function of the input, process, and outcome (Icia et al., 2014).

How the DCM will be used

The DCM displays the interplay between elements but is limited in its ability to draw hard conclusions. This model will thus be used to try and make the many different factors that influence team learning behaviour visible. Also how they intertwine will be concluded from this model.

Adding a fourth phase to the DCM

Marre Niessen (2020) describes that a phase is left out of the DCM. It concerns the phase that precedes the action or task about which the DCM revolves. This phase is left out because it consists of factors that establish the situation before the DCM is started. Once the first iteration is complete, these factors become less influential. It was said that adding this phase into the model would be ‘disproportionate’ and that these factors should be included in the input section of the model (Niessen, 2020). This then gives a more temporal view of the task.

Other researches also mention a similar phase in similar frameworks. For example, in Kozlowski & Ilgen, (2006) (Figure 11) contextual and environmental factors are mentioned. Sargent & Waters, (2004) also suggest this fourth segment to be present. In their *inductive process framework* (Figure 12), the contextual influences 'institutional supports', 'resources' and 'national & institutional climate' are highlighted between each step.

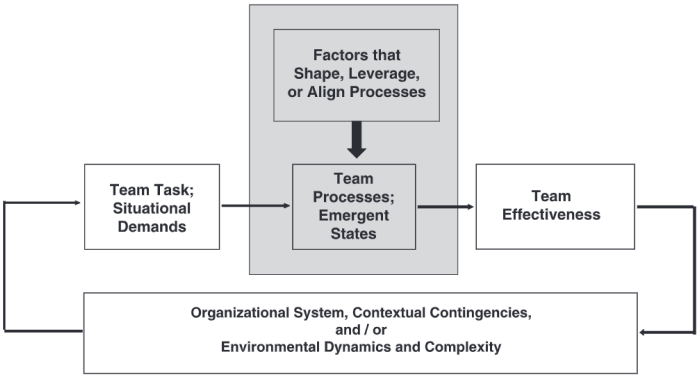


Figure 11 : Environmental dynamics and complexity drive of team tasks demands (Kozlowski & Ilgen, 2006)

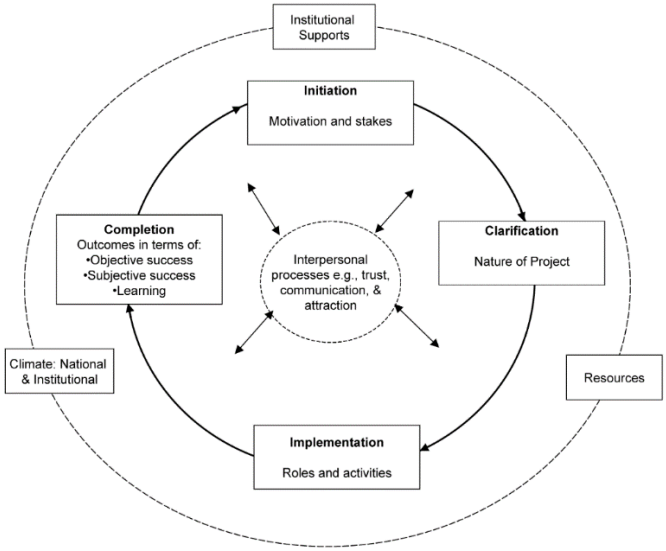


Figure 12: An inductive process framework of Academic research collaborations by Sargent & Waters (2004)

In this research, this fourth phase will be added to the DCM, to make sure that an overview using this model will cover all possible influence factors on team learning behaviour. This fourth phase will be called 'Antecedents' in this research. These Antecedents are used to adapt the DCM of Kalmar & Stenfert (2020). The Antecedents have an effect on all phases of the collaborative effort of team learning behaviour (Figure 13).

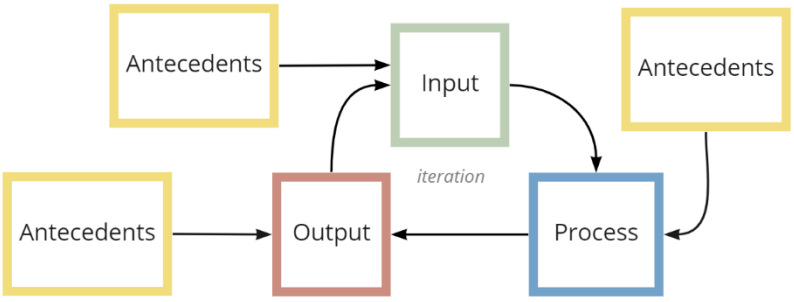


Figure 13: Adapted DCM focusing on team learning behaviour

Learning boosters and drainers

Thijs Elzer's thesis was particularly interesting because of the subject he researched. It was about team learning behaviour in a hospital. In his literature research, he describes a list of general team learning boosters and drainers. These boosters and drainers are about general organisations and are not constrained to context.

The overview is not based on a systematic literature overview, so most likely not complete. However, it gives an overview and is already categorised. Therefore, it is a good start for new research on this topic. The boosters and drainers in this overview are generic . They are categorized based on Boudewijns (2005) five clusters of organisational learning capacity. Within that model, the 'experience-related' cluster is not used, and the cluster called 'emotion-related' changed to 'affect-related'. The resulting learning boosters and drainers overview is predominantly based on Boudewijns (2005) and de Vos et al. (2017) and can be found in Figure 14.

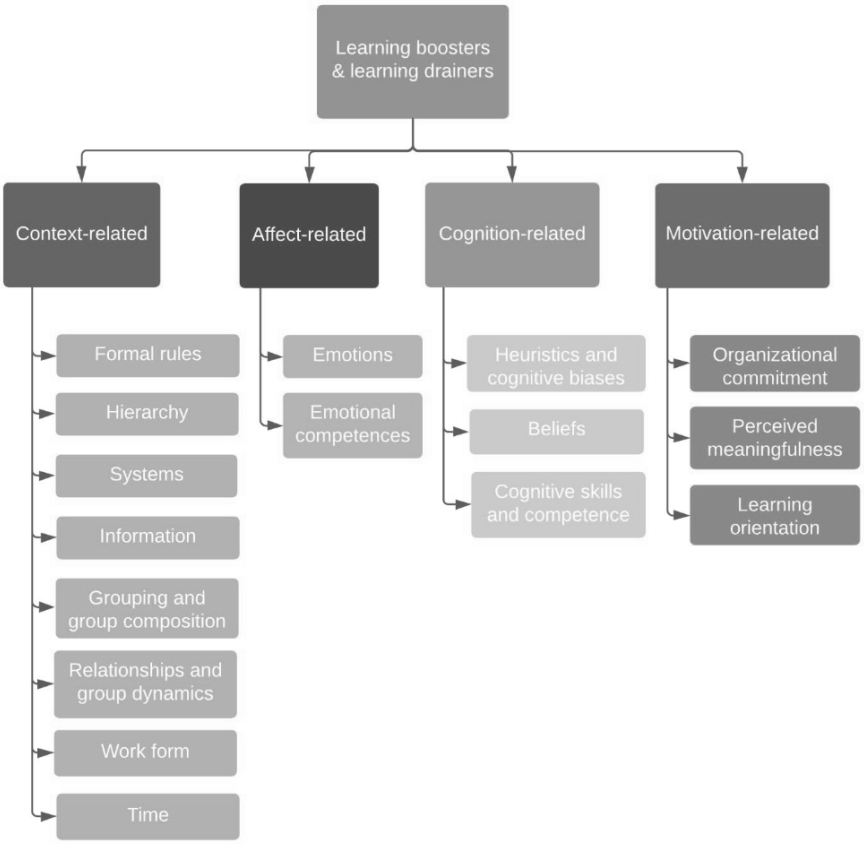


Figure 14: A clustered overview of learning boosters and drainers by Thijs Elzer (2021)

Thijs Elzer's literature review references will be used to snowball upon to find new literature.

Connecting the DCM with literature on team learning behaviour

To figure out the connections between the different influence factors and how they relate to one another, it was necessary to find more models that link theory about team learning behaviour with IPO models.

First the *model of work-team learning* from Edmondson (1999) was found (Figure 15), in which similar concepts are used as in the now adapted DCM. This can be seen in '*antecedent conditions*' as initial input and '*team learning behaviour*' as (Collaboration Effort)-Process and Outcomes.

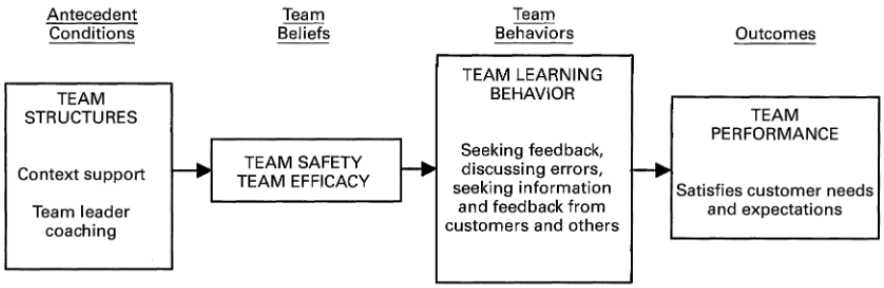


Figure 15 : A model of work-team learning by Amy Edmondson (1999)

In this model, influence factors such as '*Context support*', and '*Team leader coaching*' can be connected to the *'Antecedent Conditions'* mentioned in the adapted DCM (Figure 13). '*Outcomes*' can be aligned with '*Output*' in the adapted DCM. In the model of Edmondson (1999) '*team performance*' is used, is used for the same concept as '*team effectiveness*' in the models. '*Team safety*' and '- *efficacy*' fall under the category '*Team beliefs*'. This means the teams' general perspective or way of thinking. Although these influence factors work on the process of team learning behaviour, they are not just considered as Input, but also as Antecedents. This is because '*team safety*' and '*team efficacy*' are a changing but continuous state of the team. They work on both the input and the process of the team learning behaviour effort.

Similar relations between influence factors can be found in Kim et al., (2020). There, the quantitative influence is explored of team psychological safety on team effectiveness through team learning behaviour and team efficacy (see Figure 16).

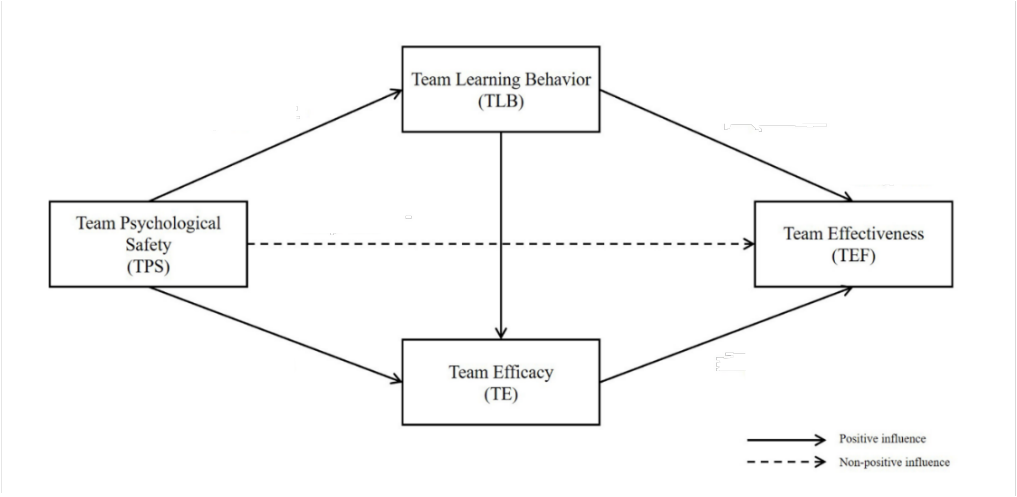


Figure 16 : Research model with regression coefficient values by Kim et al. (2020). The relation between TPS and TEF is non-significant.

This figure shows that the effect of team safety on team effectiveness is indirect and influences different surrounding factors. This research was done in sales and service teams. Therefore, during the interviews, it needs to be checked whether these relations also apply in academic collaborations.

Putting both influence factors and relations in the adapted DCM

A quick and dirty causal diagram was set up with the influence factors and relations mentioned in the model of work-team-learning by (Edmondson, 1999) Kim et al. (2020) and Elzer (2021) (Figure 17). It was mainly used as a starting point for a larger network of factors on team learning behaviour. The factors are colour coded by the adapted DCM model (Figure 13).

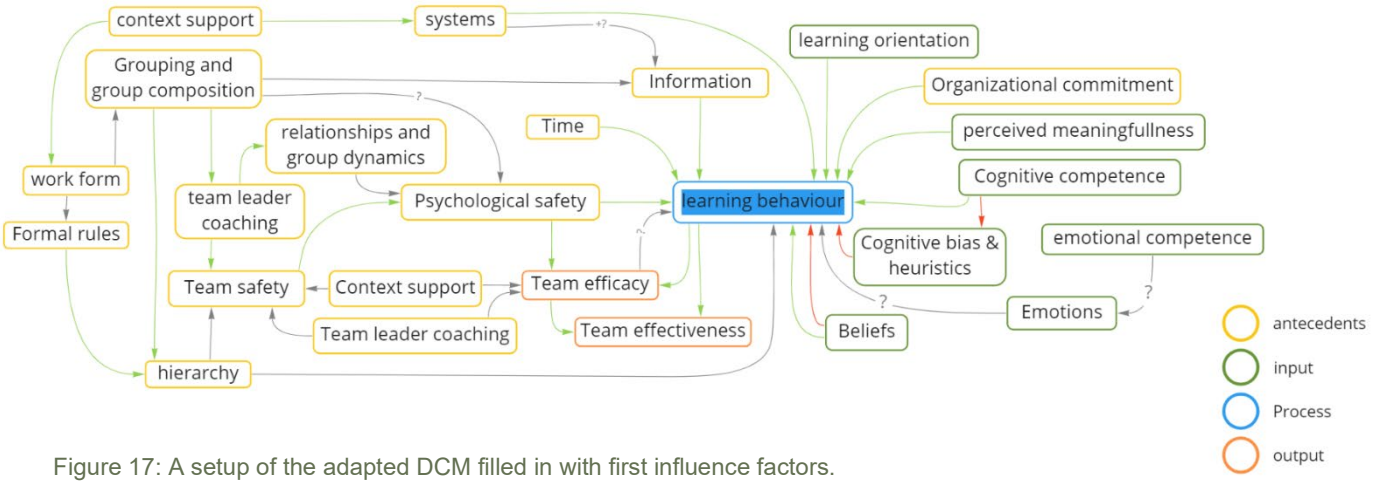


Figure 17: A setup of the adapted DCM filled in with first influence factors.

In this diagram, a green line represents a factor having a positive influence. It can be either direct or indirect and is a so-called booster on team learning behaviour (Figure 18a). A red line represents a factor having a negative influence, again either directly or indirectly. It is a so-called drainer on team learning behaviour (Figure 18b). A grey line signifies either an unsure or a more complicated relation. These factors can have both a positive or negative influence (Figure 18c).

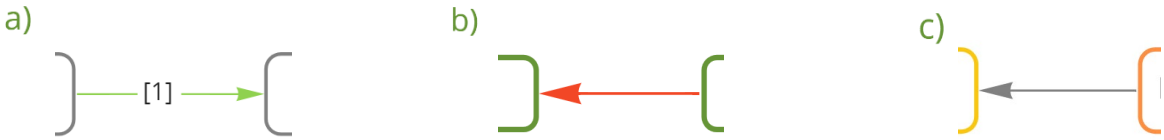


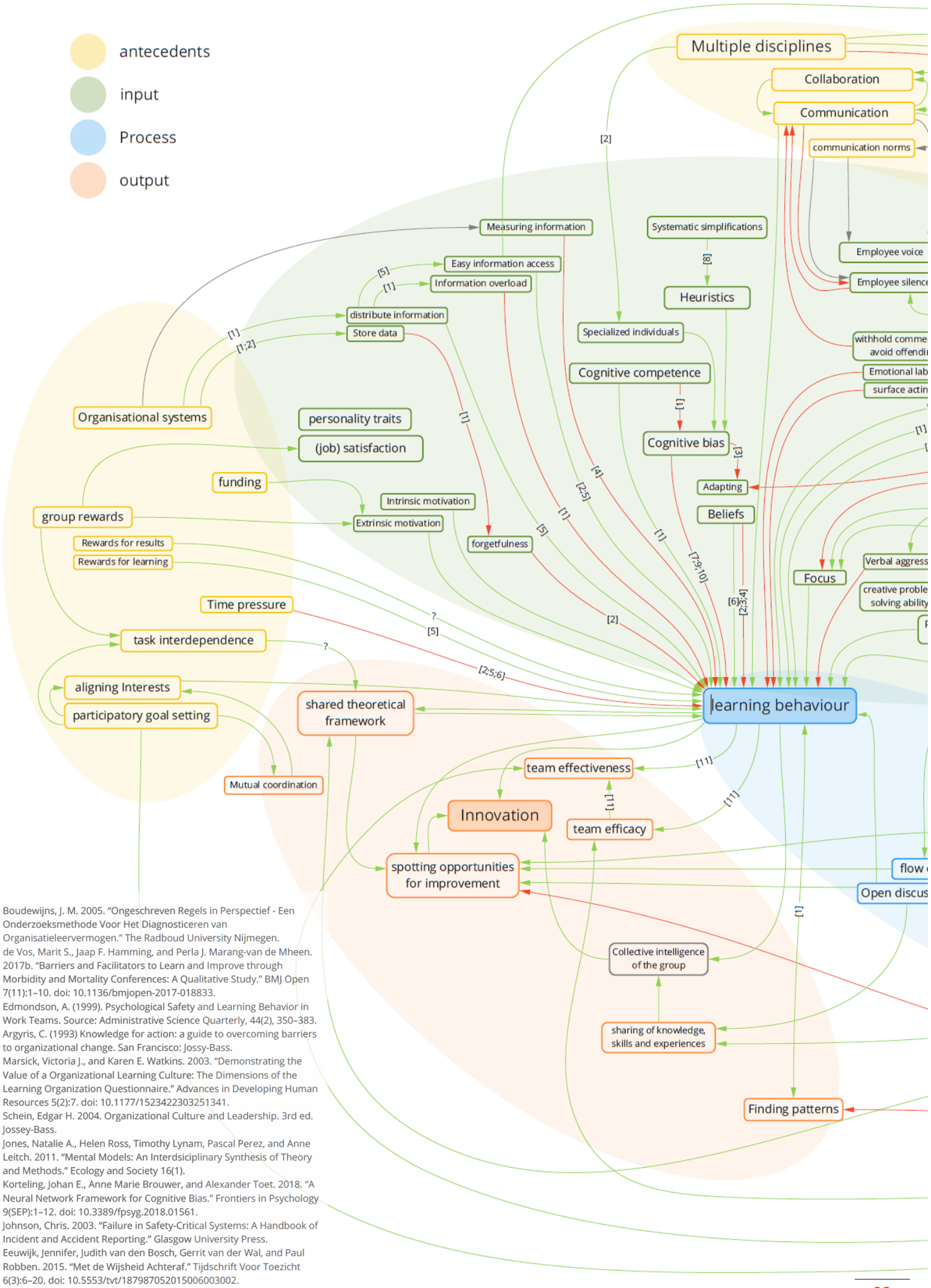
Figure 18: LTR: A literature reference in a relation between factors; A relation without literature reference; A relation which is either not clear (a), or could have a positive (b) and negative (c) influence.

New literature in the adapted diagram

After continuously adding to the diagram, both by finding more literature, but also by making connections on intuition, it has grown to an enormous format, see Figure 19 on page 19 and 23. The factors are all found in literature, as are most of the relations. These are shown by having one or multiple references cited within the arrow, see Figure 18a. The relations that do not have a reference cited are connected based on intuition. Often research was done to find either confirming or disproving literature, but in these cases nothing was found.
The links made are based on non-systematically found literature. Therefore it needs to be said this overview is not complete. That means that to further understand a specific influence factor or the relation to other influence factors, more analysis is needed.

Multidisciplinarity

Multidisciplinarity serves as both a learning booster and a drainer. Having experts from different fields can improve discussion quality and supply crucial information making it a learning booster. On the other hand, participants who are super-specialized might be less interested in topics outside their own speciality. This is how it could also act as a learning drainer (de Vos et al., 2017).



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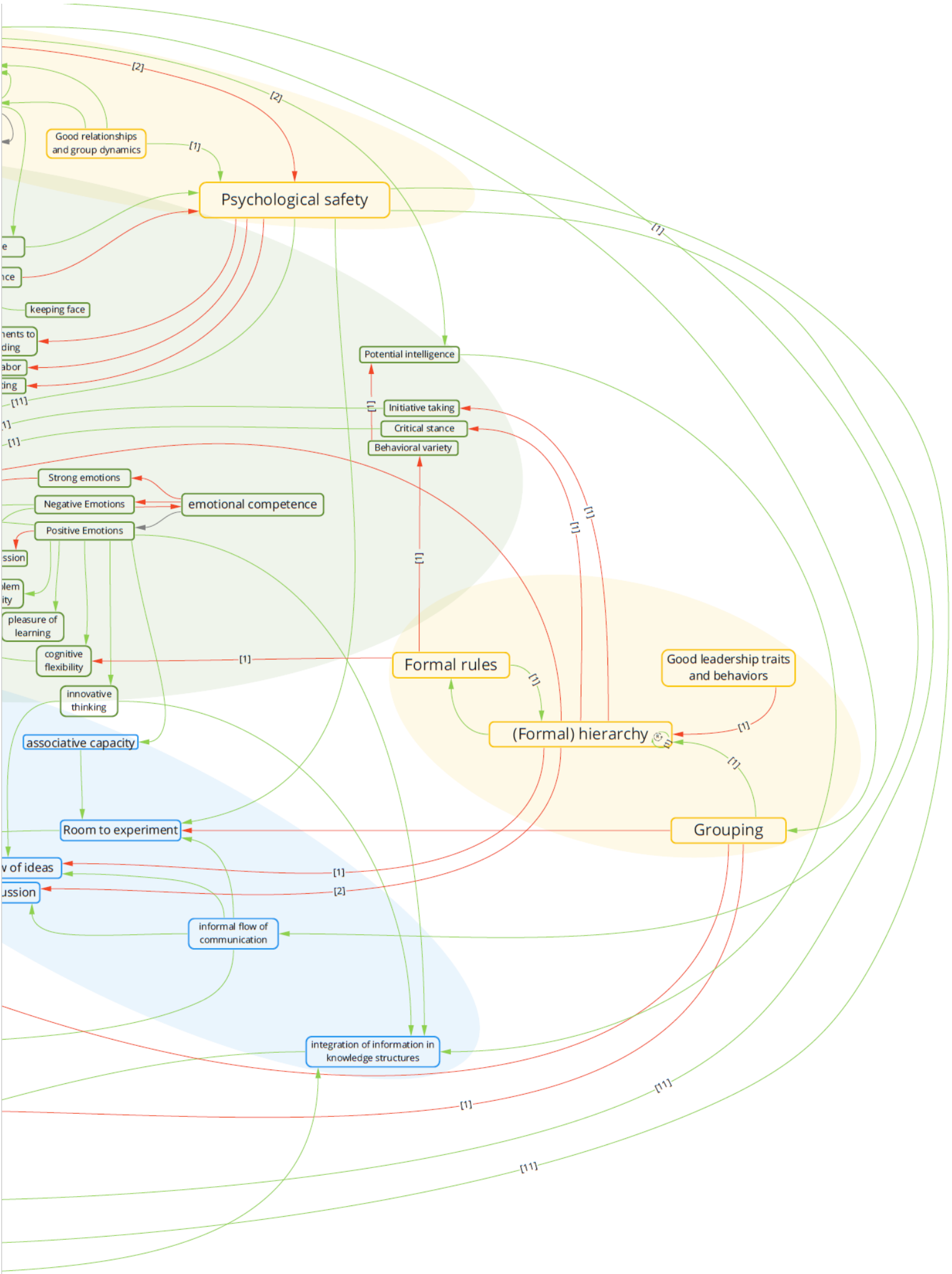


Figure 19: The living adapted diagram

2.4 Applying focus

Choosing antecedents

A choice had to be made as to what would be focused on in this research. The initial origin of this thesis stems from the wish of the Recognition and Rewards department of the TU Delft to "Stimulate teamwork and creating high-performing teams" (TU Delft, 2020). Therefore, it was deliberated what would be most practical to research for the university to be able to stimulate. The antecedents are thought to be most accessible and influenceable for the university, because the other groups, Input, Process and Output, are often more aspects that happen inside a person. Also, the antecedents are more systemic, and differ less for each effort. For this reason, the antecedents were chosen to look further into, and build interview questions around.

Grouping and extracting antecedents

When putting all antecedents next to each other, the overview showed there were too many antecedents to cover within the interviews. Therefore, it was decided to group the antecedents into themes. This was done by putting all antecedents together and grouping them where they were linked to a certain subject.

The antecedents were grouped into six themes: management; time; psychological safety; hierarchy and formal rules; setting up goals together and reward system (Figure 20).

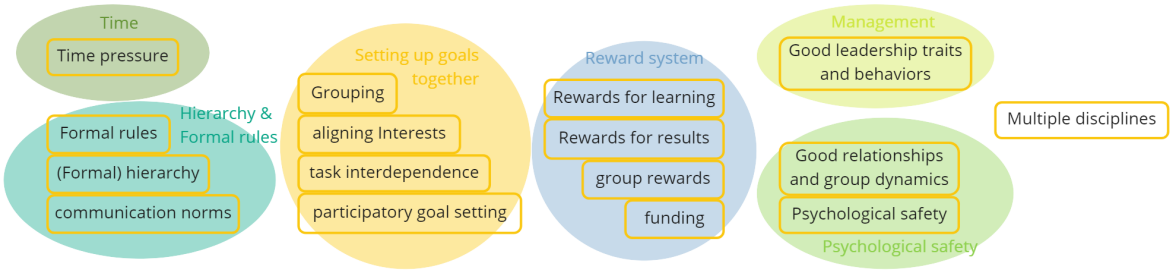


Figure 20: Overview themes of antecedents in living adapted diagram.

A closer look was taken at the living adapted diagram (Figure 19) to see if an overview can be made where only the antecedents and their connections could be extracted. This was done to create a more legible overview of what is used in the interviews. Eventually, this became two different extraction diagrams (Figure 21 and Figure 22) instead of one to increase legibility even further.

These two diagrams are split per theme of antecedents, so per theme, a diagram can be consulted to see how the corresponding factors are connected to learning behaviour and what other factors are related.

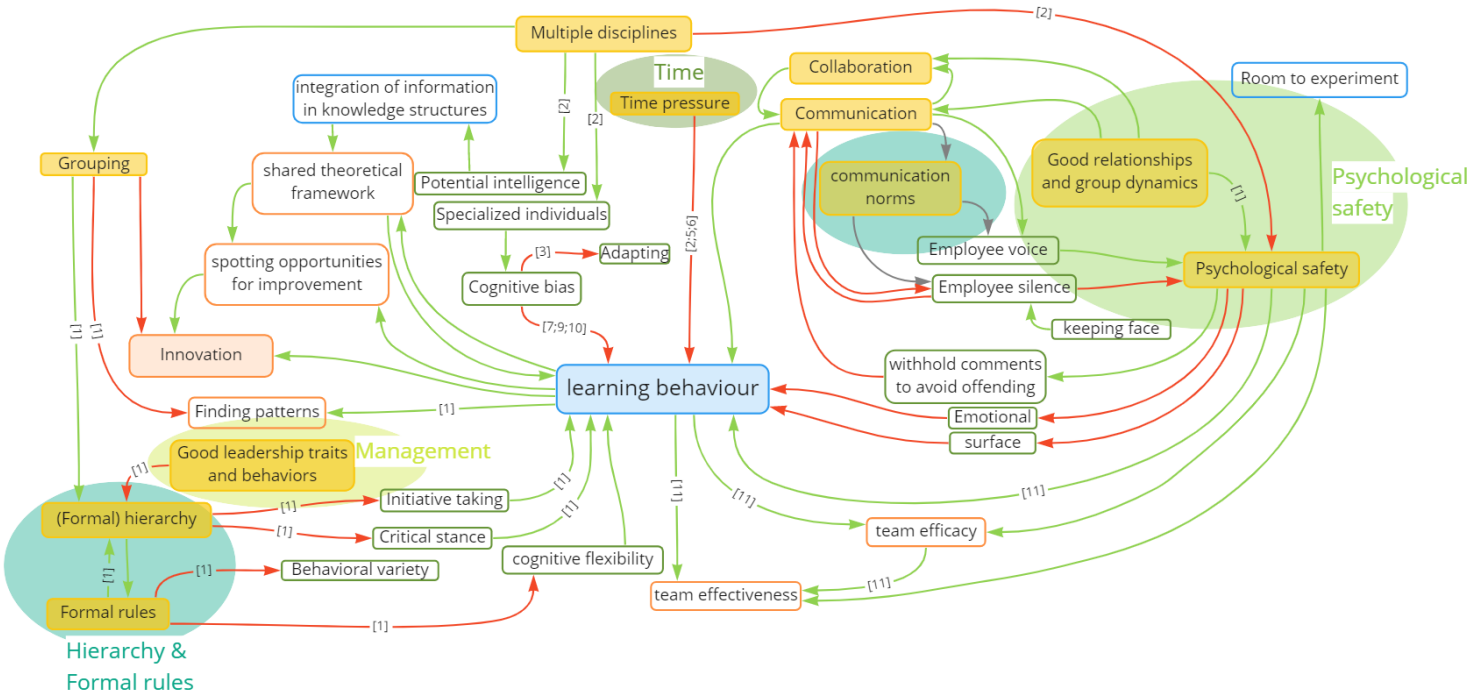


Figure 21: Extraction diagram from which groups 'time', 'management', 'psychological safety', and 'hierarchy and formal rules' are extracted.

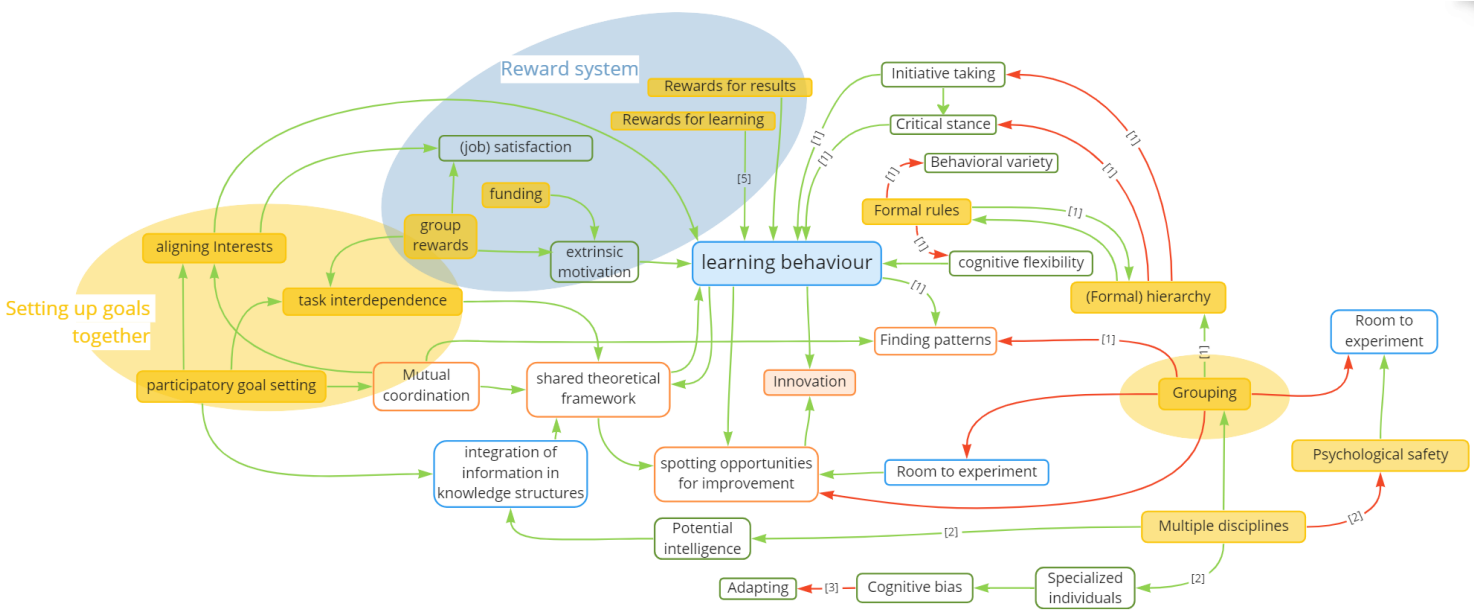


Figure 22: Extraction diagram from which groups 'setting up goals together' and 'reward system' are extracted.

Multidisciplinarity is left out of this grouping as this is a prerequisite for the collaborations interviewed in this research.

Operationalisation of the factors for the interview

Because of the semi-structured set-up of the interviews, it was possible to ask specifically about these themes, and ask follow-up questions if needed. For example, when the participants feel other factors are skipped or the interviewer thought that somewhere a bigger story should be unravelled.

A table was made (Table 1) to define what is meant exactly with the themes within the framework of team learning behaviour. These definitions are combinations of the definitions given in the literature of the living adapted diagram.

Management	"The way the group is managed and how this influences the way you learn from each other."
Psychological safety	"Gives room for people to speak up, share ideas, questions and mistakes, without fear of rejection and how this influences how you learn from each other."
Setting up goals together	"Collectively thinking about setting goals and how this influence how you learn from each other."
Hierarchy and formal rules	"Asymmetric relationships between people and strict etiquette and how this influences how you learn from each other."
Reward system	"A system that rewards (part of) the team for certain actions and how this influences the way you learn from each other."
Time	"How much time you have to collectively achieve your goals and how this influences the way you learn from each other."

Table 1: Definition of the grouped themes.

2.5 Re-specification of research questions

Because of the fluidity of the concept of transdisciplinarity, the research questions were respecified to focus on collaborations consisting of scientists working in multiple disciplines, instead of transdisciplinary collaborations. This made it also easier to decide if they fell in this target group.

1. What factors can be derived from literature that have an influence on team learning behaviour in **collaborations between people of multiple disciplines?**

2. How do individual scholars working in **academic collaborations consisting of multiple disciplines** at the TU Delft perceive their current team learning behaviour?

3. What do individual scholars working in **academic collaborations consisting of multiple disciplines** at the TU Delft think about getting help or stimulation from the university for this team learning behaviour within their collaboration?

4. How can TU Delft stimulate team learning behaviour in their **academic teams consisting of people from multiple disciplines?**

3. SETTING UP THE INTERVIEWS

3.1 Methodology

Participants

The plan was to find participants in an academic function at the TU Delft who work in a collaboration with multiple other disciplines. The type of collaboration could vary; whether it was a project, a lab or a department at a faculty, the requirement was that they work together. To keep the boundary conditions somewhat similar, the plan was to get three to four participants from four different collaborations with approximately eight to fifteen collaborators. These boundaries could be widened if no suitable groups were found. It did not matter what phase of the collaboration they were in, as long as they had been working together for more than a couple of months so they would be able to make a relevant judgement about the collaboration. Knowing that most academics at the TU Delft are always pressured for time, they need to find the topic interesting enough and be willing to make time for an interview. Participants were looked up online and checked if they work together with another discipline before requesting them to help with the research. More requests than necessary were sent out and until twelve participants were found, everyone who was approached and who was willing, would be interviewed.

Obtaining data

Semi-structured interviews were used because this allows for more flexibility of the questions. That way, the questions could be tailored to the situation the participant was in and the story they were telling. side-tracks in the answers could be encouraged if they were deemed interesting and on topic. This is important because the goal was to gain more insight into the participants' situation, experiences and thought process around team learning behaviour. While the questions were based on findings in literature, it is possible that for academics at the TU Delft, specific topics or factors could be relevant. This should also be explored in the interviews. Also considering questions about factors in relation to team learning behaviour, it could be quite challenging for participants to answer the question. Telling an associated story about the same subject is much easier. However, being able to redirect was in this case essential. The main goal of the interviews was to get a perspective on the chosen influential factors and the antecedents on team learning behaviour. That way, we can see if the influence found in the literature was also true for academics in teams consisting of multiple disciplines at the TU Delft. Another goal of the interviews was to understand if and how the participants see a role for the TU Delft in stimulating their team learning behaviour.

3.2 Interview protocol

The interview was built-up gradually (Figure 23), to ease into the more difficult and personal subjects. It was designed to slowly let them start to think more in depth about their collaboration. That way, more useful information could be gathered from the interviews. It was thought that answering direct and complicated questions e.g., regarding where in your collaboration improvements could be made, might sometimes be too difficult or uncomfortable for participants. Therefore, the interview started with something simpler, such as just explaining their situation.

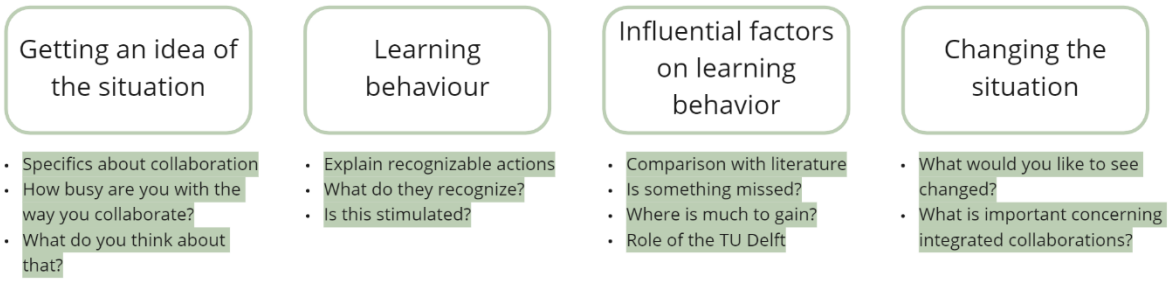


Figure 23: Build-up of the interview.

Recognizing team learning behaviour

When asked if they recognize team learning behaviour, it can be expected that this is difficult for participants answer on the spot. To help them with this, five actions that are described by Edmondson (1999) and 'making knowledge concrete' (the last step of the learning cycle of Gibson & Vermeulen (2003)) were given to the participants in random order. This was a starting point for them, see Figure 24: Recognizable team learning behaviour actions for participants. It is clearly stated to the participants that these actions need to be talked about and discussed openly within the team. Otherwise they represent individual learning behaviour instead of team learning behaviour.

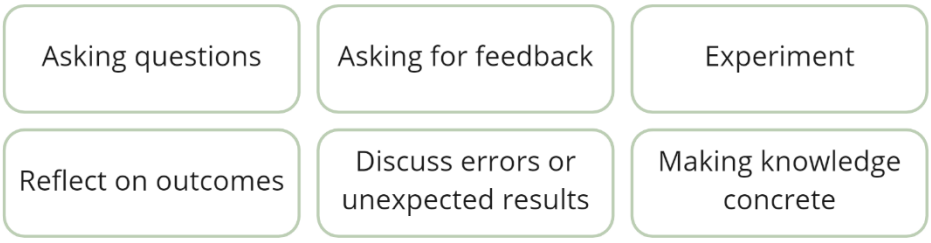


Figure 24: Recognizable team learning behaviour actions for participants.

One of the goals of the interview was also to find an area to design a solution for, this is going to be one of the themes from the antecedents that came out of the living adapted diagram. The participants were asked to rank these themes based on influence on learning behaviour. These six themes were presented to them in a random order, in order to avoid bias. They were all printed out on cards which were shuffled and laid out on the table (Figure 25). Then, the participant was asked to choose a theme and talk about that.

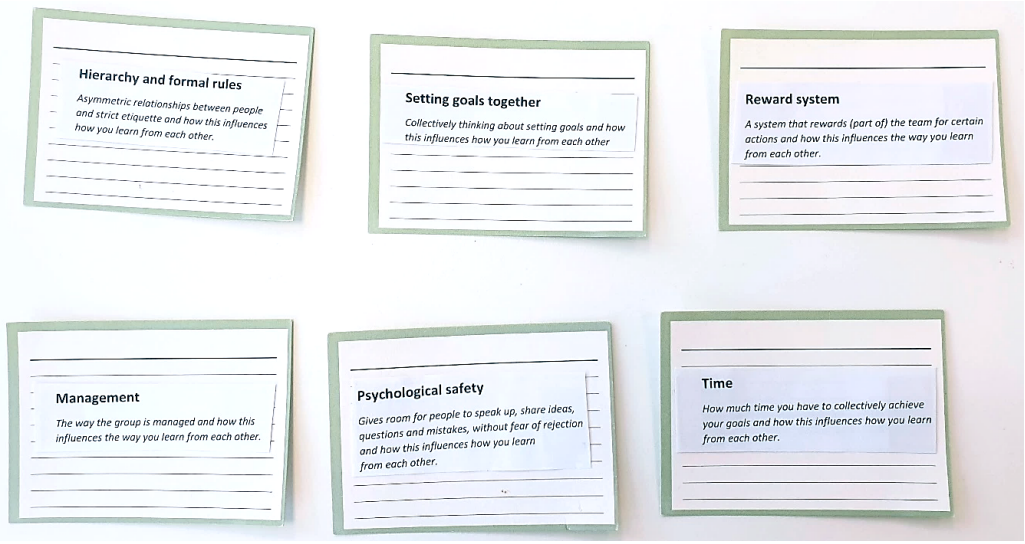


Figure 25: Cards that were shown to the participants during the interviews.

An explanation of what is meant was written underneath to make sure the process was started with the same meaning of the word. They were given the time to read through these concepts and ask questions before starting.

Final interview protocol

Before the interview, a consent form was given, this can be found in Appendix A.

The interview questions were built up using Figure 23. If the interview was taking too much time or the participant only had half an hour, some questions with less priority could be skipped over. These questions are put in grey.

Interview questions

An overview is made with the interview questions and what part of the setup they were made for Table 2. The whole written out interview protocol can be found in Appendix B

Theme	Questions	Comments
Getting an idea of the situation	Which collaboration you participate in will we use for this interview	Easing them into thinking about their collaboration and mapping collaboration
	How integrated are you in your collaboration (show figure)?	
	Your background and the difference from the people you work with?	
	What is your common goal and what is your part in working towards this goal?	
	Do you talk about the way you (should) collaborate together in your team? (Reflective & planning? Is this easy or hard? Did this change over the course of time?)	Shifting attention towards collaboration and metacommunication
	How do you feel you should be busy with this? More/less?	
Team learning behaviour	Do you recognize any of these learning behaviour activities in your team? (Show figure) Are there other activities that you can think of, with which your team learns from each other?	Explain learning behaviour and see if they understand and recognize
	Do you have agreements or systems to do or stimulate these activities? What is easy/hard?	
	What could help you with this in the future?	What help could they use?
Influence factors on learning behaviour	Can you tell me, for each of these six factors, if it is a factor that could influence team learning behaviour in your opinion? If so, would it have a positive or negative effect? I would like you to think out loud and explain why, so I can follow your thoughts.	How do they experience the grouped antecedents?
	Within your group, is the amount of **time/ Psychological safety/formal rules and hierarchy/ reward system/ management/the way goals are being set** something that works for or against team learning behaviour at the moment? How/why?	They get to choose the order in which to go over these
	Is there another factor that helps or hinders you?	What can they think of now, that is they deem important
	Could you sort these factors on how much effect they have on team learning behaviour within your group?	What could be focussed for solutions?
	On which of these factors do you think there is a lot to gain still within your group to support team learning behaviour?	
	Would you want the TU Delft to help with this? Why/How?	What help could they use?
How would they do it differently?	If you got to change something within your current group, what would that be?	What would they focus on intuitively
	What makes collaborating different when being very dependent on each other? Is there something specific you have to watch out for?	
Closing questions	Is there something we haven't talked about that you think is important?	Getting more interview participants
	Is there someone of whom you think it would be interesting for me to talk to?	
	Is it okay if I keep you posted on the research and as soon as I have designed something, I could run it by you for feedback?	

Table 2: Interview questions semi-structured interviews

3.3 Participants

Through an already existing network within the university of students and professors at CDI, three collaborations were reached out to. These also inherently combine multiple fields and were asked if they were open to have approximately four of their people be interviewed for this thesis research. Only one group was enthusiastic to have four people interviewed, from the other groups there were one or two positive responses.

After each interview, the participant was asked if they knew anyone else who was in a similar collaboration and willing to participate. Snowballing like this, around 25 extra names were suggested, of which 18 seemed to be working with people from different disciplines when looked up online. All 18 were asked to participate and everyone who was willing and able to do so within a certain timeframe was interviewed. In total this resulted in 13 participants from 7 different collaborations, who can be found in Table 3.

Participant	Faculty	Function title
1	Electrical Engineering & Applied Sciences	PhD candidate
2	Electrical Engineering & Aerospace Engineering & Mechanical, Maritime and Materials Engineering	Associate professor
3	CDI & Industrial Design Engineering	Double degree CDI student
4	Electrical Engineering & Mechanical, Maritime and Materials Engineering	Department Head
5	Architecture	Assistant professor
6	Technology, Policy and Management	Postdoctoral researcher
7	Electrical Engineering & Applied Sciences	Associate professor
8	Computer Science	PhD candidate
9	Technology, Policy and Management	Postdoctoral researcher
10	Computer Science	Postdoctoral researcher
11	Computer Science	PhD candidate
12	Computer Science	Associate professor
13	Computer Science	PhD student

Table 3: Interview participants for this thesis.

The first interview had been a (successful) pilot. However, the second interview was not as successful, possibly because of the questions. After this interview, there was doubt if this participant answered the questions well enough to process the results from this particular interview. As an extra check on the clarity of the questions, a second pilot interview was done with the third interviewee, a fellow master CDI student who is also participating in a multidisciplinary project. This pilot was again successful. After six interviews, it was decided that participant #2 had been an outlier in not answering the questions and simply talking about what associations came up. Hence, interview #2 was excluded from further analysis. All other interviews were considered successful.

4. RESULTS OF THE INTERVIEWS

4.1 Methodology

All interviews were transcribed using intelligent transcription. An interpretation was made to exclude pauses, stutters, filler words and non-anonymous characteristics where possible, to create an understandable text. The data from the transcripts were coded in ATLAS.ti by using deductive coding according to research questions using descriptive codes. Then a closer look was taken at the similarities and differences between respondents. Patterns were searched for using ATLAS.ti code-occurrence and cross tabulation analysis. A communication chart was made to provide a clear overview and to group results. These were analysed to state the final results.

Meta-data interviews

To give an overview of the data used, some general meta-data is given about the interviews held (Figure 26).

13 interviews
12 hours of recording 154 pages of transcription
474 quotations divided into 53 different codes

Figure 26: Meta-data of interviews.

Coding Analysing

Deductive coding was used in ATLAS.ti, according to research question 2 and 3. Research question 2 was split into two parts, covered by part A and B. Research question 3 is covered by part C.

- **Group A** (Figure 27) concerns the general experience and what participants think.
- **Group B** (Figure 28) is about what participants think about the influence factors found in literature and what other factors they deemed important.
- The third group, **Group C** (Figure 29), talks about what the participants would want to see changed and how they view that TU Delft could help.

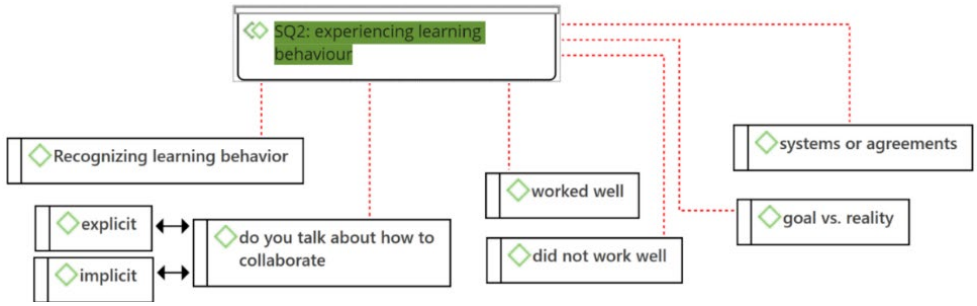


Figure 27: Group A: Coding for answering the first part of research question 2.

Figure 28: Group B: Coding for answering the second part of question 2.

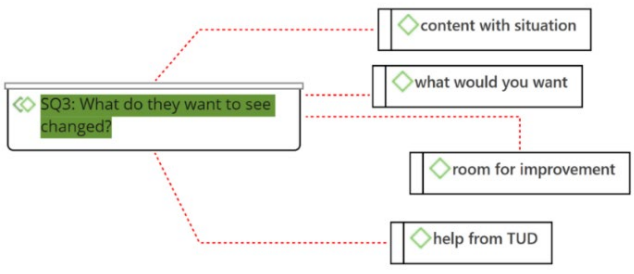


Figure 29: Group C: Coding for answering question 3.

Some specific coding that is used, was directly asked in the interviews, such as 'Would you like the TU Delft to help?'. To make sure no comments were missed, for each code a list of words was compiled to signal whether a code is applicable to that piece of text. These lists, combined with intuition and common sense was used to allocate coding to pieces of text. For the lists with signal words see Appendix C.

Other codes were also used and thought of while coding the texts, such as "feeling pressure for time". This is to see how many participants talked about the same thing or to divide the factors into learning boosters and drainers.

For example, a coding of a quote of participant 6 can be found in Figure 30.

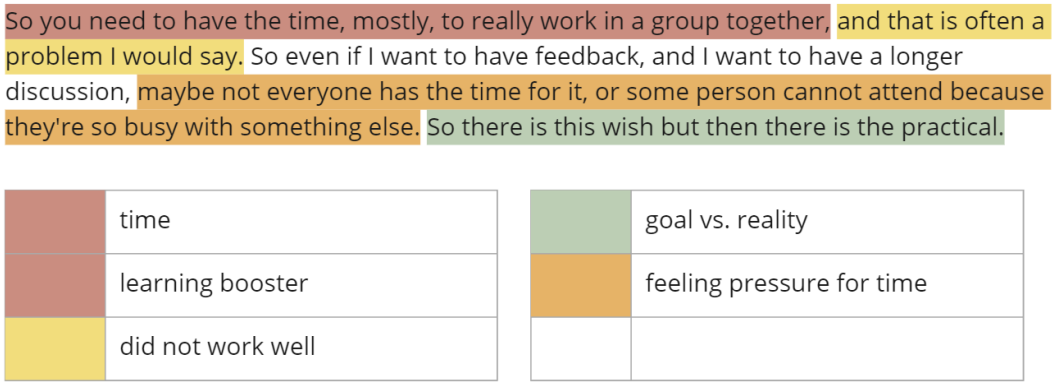


Figure 30: An example of the coding of a quote.

4.2 Results part A: Perceiving learning behaviour

Perceiving learning behaviour was split up into four categories (Table 4).

Recognizing learning behaviour	Meta-communication	Integration of collaboration reality vs goal	Systems or agreements they use

Table 4: Four categories of perceiving learning behaviour as used in the interview.

Recognizing team learning behaviour

When asked if they recognized team learning behaviours by means of the actions given in the interviews, every participant answered yes.

When asking more in detail what they recognized (Figure 31), most of them referred to more abstract actions such as 'asking questions' and 'asking feedback' as these are the ones that happened the most. 'Making knowledge concrete' was named as the most difficult by four participants. Participant #8 said *"When you make knowledge concrete, there is tension. You lose a little bit of the scope of the initial idea, because you go from conceptual to clearly defined to actually do something with it. This is a constant dilemma." [#8]*

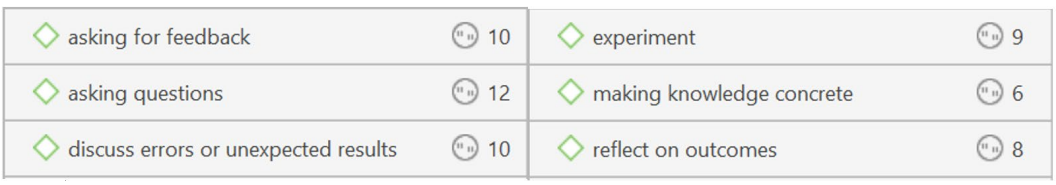


Figure 31: The occurrence of the recognizable team learning behaviour actions based on Amy Edmonson (1999) with n = 12.

Participants #1 and #11 said they did not recognize ‘asking for feedback’. They said this was because they felt that asking someone from another discipline within their collaboration for feedback often was no help to them. The reason for this was that the other disciplines did not have enough knowledge to give them useful feedback. These two people came from very different types of collaboration. The level of integration was respectively low with participant #1 while it was high with participant #11.

Participant #6 said that all learning behaviour was recognized. However, they could not make it work online and needed face to face contact for this kind of learning.

Metacommunication

When asked if they talk about the way they communicate and collaborate, the participants gave many different examples. These were labelled during coding as implicit or explicit.

An overview (Figure 32) shows that many collaborations do not explicitly talk about their metacommunication.

	1: 3	2: 3	3: 4	4: 3	5: 4	6: 3	7:	8: 4	9: 3	10: 54	11: 49	12: 3	Totals
explicit 13		1	5	3			1			2	1		13
implicit 20	1		2	1	2	3		5	5			1	20

Figure 32: Metacommunication examples given, labelled explicit or implicit per participant.

In these situations, if team learning behaviour takes place, this *“happens spontaneously” [#1]*, “*just evolves” [#8]* or is tried to make into a culture, e.g. something people ‘just do’ in that group. Participant #4, who is in a managing function in the collaboration said: *“[The metacommunication] seems fine, [because] no one came up to me and told me otherwise.”[#4]* All participants answered that they want to spend more time and energy on this. Four participants even stated they have a desired goal to work together in a more integrated way and are working towards that goal with the people in their collaboration.

Systems and agreements that are currently in place

When asked about systems or agreements that are in place to help them or stimulate their team learning behaviour, a lot of answers were the identical across the different collaborations (Figure 33). All participants stated they have regular meetings, although these are executed differently. Some participants added that they have a particular system with these meetings. They either have a separate meeting for separate goals or rotate the people responsible for the meetings.

The second answer, which was often mentioned, is that a lot of collaborations have a form where the participants go away together for a couple of days, a retreat or weekend in the countryside.

	1	2	3	4	5	6	7	8	9:	10 5	11 4	12 3
days away... 6			1						2	1	2	
meeting 21	1	2	1	2	2	1	2	1	2	4	1	2

Figure 33: Most frequently answered examples of systems and agreements per participant.

The last frequently given answer was that participants felt that the moments where team learning behaviour took place, were often not planned but just happened as a happy accident.

4.3 Results part B: Themes that influence learning behaviour

The themes made from the clustered antecedent factors out of the adapted living diagram that came from literature, were then checked with the participants. Moving forward, these themes will be called the six influence factors. First it was researched if the participants think the factors discussed are a learning booster or drainer. This was asked directly and the answers are clear for five out of six of the factors. For the last factor, the reward system, the opinions of the participants were too varied to lead to a clear conclusion (see Table 6).

Praticipant	Psychological safety	Time	Setting up goals together	management	formal rules and hierarchy	Reward system
1	booster	booster	booster	booster	drainer	booster
2	booster	both	booster	booster	drainer	booster
3	booster	booster	booster	booster	drainer	booster
4	booster	booster	booster	booster	both	drainer
5	booster	booster	booster	booster	drainer	both
6	booster	booster	booster	not discussed	drainer	booster
7	booster	booster	booster	booster	drainer	booster
8	booster	booster	booster	booster	drainer	booster
9	booster	booster	booster	booster	drainer	both
10	booster	booster	booster	booster	drainer	drainer
11	booster	booster	booster	booster	drainer	drainer
12	booster	booster	booster	booster	drainer	drainer
conclusion	Learning booster	Learning booster	Learning booster	Learning booster	Learning drainer	Unclear

Table 6: Participants answers to learning boosters and drainers.

Praticipant	Psycholo-gical safety	Time	Setting up goals together	mana-gement	formal rules and hierarchy	Reward system	other factors named	most room for improvement in:
#1	2	not discussed	1	2	4	not discussed	physically together	psych & mngmnt
#2	2	6	1	3	6	not discussed	physically together	hierarchy
#3	2	not discussed	1	3	4	4	enough space	set goals tgthr
#4	2	3	1	3	5	6	talking the same language	set goals & mngmnt
#5	4	2	3	1	5	6		set goals tgthr
#6	not discussed	not discussed	not discussed	not discussed	not discussed	not discussed		management
#7	1	5	4	2	2	6		set goals tgthr
#8	not discussed	not discussed	not discussed	not discussed	not discussed	not discussed	diversity (people and background) & openmindedness	time
#9	3	4	1	4	1	4	know someone personally	(individual) mngmnt
#10	1	3	not discussed	not discussed	1	not discussed	know someone personally	reward system
#11	2	5	3	1	6	4		reward system
#12	1	4	3	2	6	5		time (to collab)
average	2	4	2	2,33	4	5		

Table 5: Relative ranking of importance of influence factors by participants, 1 being most important and 6 being least important.

Psychological safety

Psychological safety was experienced as being present by all participants in their current collaborations. They are generally happy and content with this. They also note that they find this factor is relatively one of the most important (see Table 5). Psychological safety indirectly stimulates team learning behaviour. It is also named as one of the two factors becoming increasingly important when multidisciplinary collaborations becomes more integrated. When the people in the group diversify it might be even more difficult to create an open environment, where you can speak your mind.

There were no issues found at the moment with the influence factor psychological safety.

Time

Eleven out of twelve participants agreed on the influence factor time. They said that given more time, there is more space and freedom to learn from each other. Not taking the time is mostly due to having many other responsibilities and deadlines that have to be dealt with. Spending more time learning from each other, is said to have lower priority than other possible activities and is not mandatory.

Participant #2 had a different perspective, but they also indicated that they could see how this could differ from person to person:

"When I have more time, I am inclined to think I will figure it out myself, it is now not important enough to bother others with. When I, or a project is stressed for time, I will more easily search out other people for help." [#2]

The participants think that relatively, time is not that important to their team learning behaviour (Table 5) but when asked, they do want to spend more time on this.

Two participants note that having less time causes people to withdraw more into their own individual work, because this requires time and has priority (Table 7).

Time is a constraint now and they want to spend more time	*"Being more busy with it would be better" [#1]*
	"[the amount of time spent on learning behaviour] is too little, way too little." [#3]
	"Time is always a constraint" [#4]
	"You need to have time to really work in a group together, and that is often a problem" [#5]
	"The time to do meetings and explain and explore is very important as well" [#12]
	"The less time we have, [the less learning behaviour we tend to show]" [#6]
Pull towards individualism because of less priority	*"When my colleague got stuck in his progress for a few months, we stopped the weekly meetings." [#12]*
	"We constantly drift further apart … [managers need to make sure] that they are brought back together and keep the connection" [#3]

Table 7: Overview of issues with the influence factor time with quotations.

Setting up goals together

Setting up goals together is most often named as the most important relative to the other factors discussed and also named as the factor with most room for improvement still (Table 5).

"To be able to come up with a goal together, it means you [have to be] talking the same language and have interest in the other person meeting their goal. So this has a very strong impact on learning as a team." [#5]

Setting goals together is also named as one of the two factors that become increasingly important when the multidisciplinary collaboration becomes more integrated: *"[in more integrated multidisciplinary collaborations] you need more time to understand what everyone is doing and to explain. You need to do [setting up goals] together because you need everyone's expertise." [#12]*

The participants connected setting up goals together to getting knowledge concrete, one of the practical team learning behaviour actions as formulated in the interviews. This was also given as a reason why setting goals together is not going as well as hoped and they feel they need to do better.

Setting goals together is seen as very important	*"Setting goals together is the most important factor" [#3]*
	"Setting goals together, you have to compromise and be critical at the same time. … that is very important." [#8]
	"Setting goals together has the most positive influence on learning behaviour" [#2]
	"Setting goals together is really important in my experience" [#4]
	"Setting goals together becomes more important [when you work more integrated] because you need to understand and explain and reflect together" [#12]
Getting knowledge concrete is a barrier, tied to setting goals together	*"Standards of the [different] fields are different. So it is very hard to converge and make specific what it means in the end. So this we struggle with" [#10]*
	"When you make knowledge concrete, there is tension. You lose a little bit of the scope of the initial idea, because you go from conceptual to clearly defined to actually do something with it. This is a constant dilemma" [#8]
	"The most difficult is getting the knowledge concrete, while everybody is content" [#11]

Table 8: Overview of issues with the influence factor time with quotations.

Management

When talking about management as a learning booster, this is mainly indirect. Participants stated that when good leadership behaviour is shown, other factors that stimulate team learning behaviour will work better. Examples given of 'good leadership behaviour' are: setting up the right structure, connecting the right people, organising the right activities, etc.

Management was given as one of the factors with most room for improvement was (Table 5). This is mainly because participants find that management is not done the right way. Even one participant, who is in management herself, says she is not doing it right, because she does not know how. How leadership can stimulate team learning behaviour is stated by multiple participants to be: creating the framework or setting in which team learning behaviour can flourish.

Management works indirectly through all other factors on team learning behaviour	*"good management sets up how the learning behaviour works .. This is the most important factor" [#5]*
	"management should be directed to creating the environment that facilitates learning from each other" [#7]
	"management needs to give a good example of the culture" # [3]
	"It's the job of the manager to connect people" [#4]
	"Management is most important, that's where it starts" [#11]

Table 9: Overview of issues with the influence factor management with quotations.

Formal rules and hierarchy

The perceived presence of rules and hierarchy is varied between participants, but if it was there, it was often experienced as not being very prominently present. It was not described by any participant as getting in the way of team learning behaviour in their current collaboration. Only participant #3 described that they saw hierarchy play a part in their collaborations: *"As a university, we are by design a very hierarchical organisation. We might not want it, but we are. So [as a manager] I try to tell researchers: you are now your own institution, you have to stop asking for permission and take responsibility. This is how they will fail or succeed." [#3]*

Reward system

When asking about the reward system, there were many different and contradictory answers given by participants. This causes a difference in the perception of it being a learning booster or drainer (see Table 6).

The participants who described the reward system as being a learning booster, talked mainly about rewards in the form of either moving up in their career or rewards in the form of attention from colleagues. When talking about attention, examples given are: colleagues being interested in their work, listening to their explanations and asking questions. When asked about more materialistic rewards, all participants agree on the fact that they do not want this, nor do they think this would be stimulating.

The participants describing the rewards system as being a learning drainer, talked about the reward system that is currently in place. It does not work for them or excludes them and their integrated multidisciplinary work. In these cases the reward system is counterproductive and makes them feel that if their work is not rewarded within the system in which they work, why even do it? Talking about integrated multidisciplinary collaborations, they stated: *"The way you're rewarded in academia doesn't really contribute to [acquiring new] knowledge. If [I'm talking] about us being an interdisciplinary unit, then I feel like the reward system is almost irrelevant. It could even be working in a negative way, demotivating people that are not getting these rewards." [#11]*

Note that the reward system is relatively not seen as a very important factor for team learning behaviour in their current collaborations (see Table 5).

Different experiences of a reward system	*"I wouldn't know a reward we want, well giving attention to people" [#2]*
	"Authorship is a reward people want, which is difficult to share in multidisciplinarity" [#9]
	"The reward system is [focused on] getting tenure or UHD" [#3]
	"I don't care much about rewards, [just that something is acknowledged as mine]" [#4]
Negative rewards for integrated multidisciplinary collaborations	*"In the interdisciplinary field, chances are, you're going to be publishing at venues that are not going to benefit your career as long as your career trajectory is determined by your publication list and your H-index. No hard-hitting publications, no matter how important everybody in both fields think your work is. [So, then you write about subjects in a way that brings you forward in your career]" [#10]*
	"The current scientific reward system contributes negatively to learning behaviour and collaboration. The peer review system .. the publication system .. will shine light on incremental monodisciplinary work easier. [Here is so much room for improvement]" [#11]

Table 10: Overview of issues with the influence factor reward system with quotations.

Other Factors

Other factors that are named as important influence factors on their team learning behaviour are: being physically together, having enough space to collaborate, talking the same technical language, open mindedness, diversity and knowing someone personally.

4.4 Results part C: Where is help wanted

Although most participants stated to be content with the current situation, when asked if they thought the TU Delft could help, a variety of things are mentioned. A couple of statements were straightforward, focussing on eliminating the learning drainers and amplifying the learning boosters, such as:

More rewards for collaborative work. [#10;#11;#12]	*More help for managerial tasks [#4;#5;#9]*
More time and means to collaborate. [#4;#5;#12]	*Getting help with setting goals together [#7;#8]*

There were also a couple of statements not connected to previously discussed topics, such as:

A TU Delft wide accessible collective memory on how to collaborate. [#10;#11]	*Attracting the right people when hiring. [#3;#6;#8]*
Teaching of collaboration skills. [#1;#4;#6]	*Improve discussing potential problems beforehand. [#2;#8]*

A couple participants have expressed they would really like to find likeminded people at the university with whom they could talk about best practices. *"Now we're all inventing the wheel by ourselves, which were doing pretty well, but it would be really nice if we wouldn't all have to come up with it by ourselves. … I would love to learn from other people, but I wouldn't know where to go. I would love to help make this more integrated way of working more visible, but what we are doing is hard enough. I don't want to put that extra burden on my people at the moment." [12]*

When asked how they view the TU Delft could offer help with these issues, roughly half of the respondents say that that would be difficult. The issues are very team specific. The other half of the participants do see potential for the university to stimulate team learning behaviour. Some see a role for the university in helping with the improvements stated above, others see bigger opportunities such as:

A clearer backing of the university, that collaboration is stimulated. [#10;#11]	*Multidisciplinary labs should get a mandate to graduate and hire people, creating positions for transdisciplinary positions. [#3;#6]*
Make collaborative work more than extracurricular. [#8;# 9;#12]	*Adopt more contemporary publication standards. [#10;#12]*

A list of all the coded pieces of text will be in a separate appendix. This will not be uploaded onto the repository with the rest of the research because of privacy issues.

5. INTERPRETATION OF RESULTS

5.1 Comparing literature in adapted DCM model with results

In Table 6, which factors were considered learning boosters and which learning drainers is presented. These conclusions are based on the participants answers. They coincide for five out of six factors with what was found in literature. Only the perspectives on reward system were conflicting. This could be explained as approximately half of the participants were not happy with the rewards system currently in place. This applied not just in their own collaboration, but also in the larger institutions in which they function. Be it the university, where career advancement is see, as the general reward, or the research environment, in which acknowledgement for ones work in the form of publication and funding are the rewards.

> *"The current scientific reward system contributes negatively to team learning behaviour and collaboration. The peer review system .. the publication system .. will shine light on incremental monodisciplinary work easier. [Here is so much room for improvement]" [#11]*

The reason for this being absent in the literature research, could be that in academics, the system works differently than in for example commercial collaborations.

The reason why the reward system was ranked (Table 5) very low in importance relative to other influence factors, could be because it is not working for them now. To stay motivated they therefore had to reduce the importance of the reward system in their mind. If better fitting rewards were defined the reward system could possibly work as a motivational tool.

5.2 Different levels within results

In the results, three levels were identified where issues were experienced and where help is needed (Figure 34). In the rest of this interpretation sector these levels will be used to categorise findings.

Figure 34: Different levels identified in results.

The rest of this interpretation chapter will be structured in the same way as the previous chapter. Part A aims at research question 2a, part B at research question 2b, and part C at research question 3. Also, It will also be mentioned on which level the issues take place.

5.3 A. Perceiving team learning behaviour

Most answers given in this part of the interview are expected results: Participants recognize learning behaviour but they feel like they could do better and do more. They have some systems and agreements that work for some collaborations, but this is collaboration specific.

It is interesting to see, that no matter if the participants are successful in showing learning behaviour or not, they barely talk about the way they want to communicate, collaborate, and learn from each other. In some cases even only when an issue arises. Their learning behaviour is often not structured or planned and most of the participants found it difficult to explain how and when they learn best from each other. This is to be expected as they say they do not really talk about it explicitly, they say ‘it kind of just happens’.

Open for change

Participants say they want to be more actively involved in this so-called metacommunication. They felt that there were opportunities for learning, but did not know where. Three participants had a goal in their collaboration to work more integrated. This suggests that they are open for change.

This issue presents itself on **the collaboration level**.

5.4 B. The influence factors on team learning behaviour

Psychological safety

Psychological safety was described by all participants as being sufficiently present in their collaborations, and not named it as a factor with room for improvement. Therefore, it was decided that this subject will not be looked into further in this research.

Time and *priority*

Not having the *time* to learn from each other, as discussed by the participants, can be very much linked to prioritising learning behaviour. Literature states that working in integrated multidisciplinary collaborations requires time and effort to be put into communication and collaboration in order to be effective (Stokols et al., 2008). This is why more priority should be given to activities such as meetings, collaboration activities, discussions etc.

No prioritisation presents itself on **the collaboration level** as it is the participants in the collaboration who have to execute the activities. Neither is the prioritisation there **on the organisation level**. This is also an issue as they need to get approval for this time and prioritisation from their managers.

Pull to individualism

> *"It is difficult to keep people together and not let them 'slide' into 'keeping their head down and just work'."[#3]*

The issue that participants are not taking the time to communicate and collaborate in order to learn from each other can be quite logical. They already have to choose what to spend their time on. Furthermore the pull towards individual excellence is inherent in their job. This, causes them to consider other parts of the job more valuable to put their efforts into. Often, their direct employers think the same.

This could also be the reason why participants ranked time pressure as not that important relative to the other influence factors (Table 5). They cannot see very clearly what is to gain from spending more time on this.

This pull to individualism presents itself on **the collaboration level** as it is the participants that need to prioritise their collaborative work over their individual work. It also exists **on the organisation level** as participants have the same mindset with which they manage the participants of the collaboration. Lastly, it is also manifests itself on the **academic field level,** as the academic field is inherently individual at the moment as stated in the beginning of this thesis.

Effective learning behaviour

There is another side to this issue. Communicating and collaborating with the goal of learning from each other could possibly take academics more time than necessary at the moment. They do not know what they are doing exactly and how they could be doing it in the most effective way.

This issue presents itself on **the collaboration level**

Setting up goals together and *management*

There were two influence factors that were said to be both most important and have the most room for improvement: *setting up goals together* and *management*. It is not strange that the same factors are said to be the most important and have the most room for improvement. The factor that is bothering them the most right now would also feel as very important to them. In contrast, something that is going very well, might often be less in the centre of attention.

Setting up goals together

Possibly*, setting goals together* could be found most important because this is the main time they have to communicate and make things more specific than before. This is also where participants state that tension lies. Making things specific between disciplines, is found difficult by them. They find it easier to avoid it. Doing it alone, they experience no tension and often spend less time on it as well.

When things are still vague, people might think they are agreeing and saying the same. However, when goals have to be written down, it turns out they do not quite mean the same thing. This might make *making knowledge specific* more difficult.

> *"Standards of the [different] fields are different. So it is very hard to converge and make specific what it means in the end. So this we struggle with" [#10]*
>
> *"When you make knowledge concrete, there is tension. You lose a little bit of the scope of the initial idea, because you go from conceptual to clearly defined to actually do something with it. This is a constant dilemma" [#8]*

The difficulty of *making knowledge specific* is also linked to *speaking different technical languages* in different fields. When people think they agree, tension can arises when trying to make it concrete.

This issue presents itself on **the collaboration level**

Management

Management, or rather the managers, were mentioned explicitly by participants to be the ones who should create the framework or setting in which team learning behaviour can flourish. Therefore, it is logical to find that management was stated to be important for team learning behaviour.

Good *management* that puts up frameworks for team learning behaviour could also be stimulated. However, this would be more straightforward as there are less indirect factors that work on this influence factor.

This issue presents itself on **the collaboration level** as this is very collaboration specific.

Formal rules and *hierarchy*

Formal rules and *hierarchy* were described by participants to not be very present in their collaborations and therefore does not get in the way of their learning behaviour. As it is going well, and not named as a factor with room for improvement, it was decided that this subject will not be looked into further in this research.

Reward system in general

It is interesting that when asked about the *reward system*, most participants did not think of traditional rewards, and if they do, they do not like them. What they do like and see as a welcome reward in their current collaborations, is attention from colleagues for their research.

Negative repercussions for integrated collaborations

Some participants conveyed that they have experienced negative repercussions from collaborating transdisciplinary. They mention that this costs them extra time outside of their allocated work. For example, when a paper can only be used for one PhD dissertation while this paper was a product of integrated multidisciplinary collaboration, then one person is having to spend their own time on it.

This issue presents itself on **the organisation level** as this is about existing systems within the university.

Other negative repercussions that were experienced are fewer publishing possibilities for integrated multidisciplinary papers. It is more difficult to get the paper peer-reviewed, as a peer reviewer would need knowledge of both disciplines or they cannot peer review the whole paper. It is also more difficult to get published on a reputational platform for these are mainly specialised and usually address just one discipline.

This issue presents itself on **the academic field level** because it involves existing systems within the university. On the other hand, there are the participants that feel that the university could help with this. The university could take more of a stand that they want a change towards a better working reward system in the academic field, by actually rewarding collaboration and team learning behaviour in a way that is visible for the rest of the academic field. This way they can set an example.
Examples given by participants are: adopting contemporary publication standards, planting a flag saying they support more contemporary science practices that involve scientific communication and interdisciplinary collaboration, and the university starting to hire not on the basis of your CV. Yet, it is good to realise that this is not a dogma a single university like the TU Delft can solve on its own as academia is a global ecosystem.

This makes this issue also present itself on **the organisation level.**

> *"In the interdisciplinary field, chances are, you're going to be publishing at venues that are not going to benefit your career as long as your career trajectory is determined by your publication list and your H-index. No hard-hitting publications, no matter how important everybody in both fields think your work is. [So then you write about subjects in a way that brings you forward in your career]" [#10]*

Monodisciplinary faculties

When looking at the structures of the TU Delft, another issue raised is the fact that the organisation is inherently build-up of monodisciplinary segments, the faculties. These faculties function all somewhat as a separate company. They are the main parts of the university that have the mandate to provide education and hire academic staff. This means that if you want a position, you would need a monodisciplinary faculty to decide they want to hire you. Participant #6 said: *"You can join an institute, but the institute doesn't pay you. It's the faculty that pays you and this is a huge problem: I applied for tenure track position. I got a brilliant letter, you're an excellent scientist, you're doing a great job, but what you're doing is a different discipline, not ours. So we're not hiring you. And that would happen on all faculties. I had a Vidi grant that would support me for five years, but nobody would take me, which is incredible! This happens all the time, everybody thinks that someone should be in the ecosystem, everybody is supportive and wants this person to succeed, but the moment that you ask them: can I have a permanent position in your place? Ah no! you should be on the other side! So where are the positions for interdisciplinary people?" [#6]*

This issue presents itself on **the organisation level** as this is about existing systems within the university.

An overview of what is talked about in this chapter can be found in Figure 35.

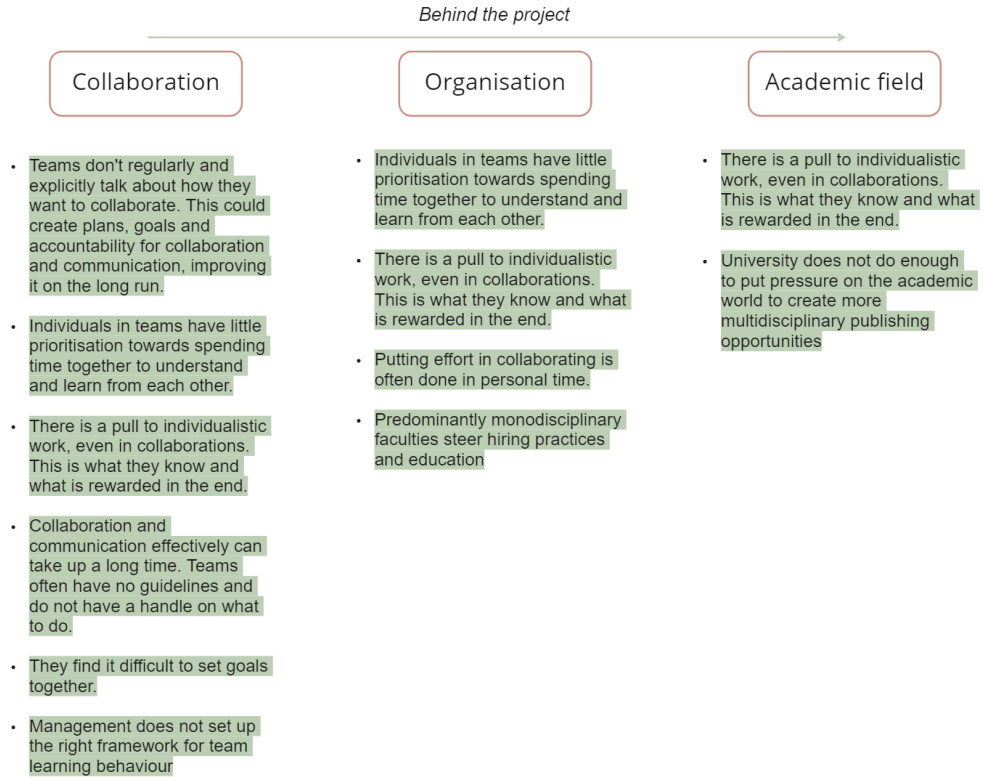


Figure 35: Overview of results divided per level.

When looking at this overview, some of the issues are connected. A categorisation can be made into three themes of issues that take place (Table 11):

- **Not prioritising learning behaviour**, of which a pull to individualistic work is a big part. This takes place on *all three levels*.
- **Non efficient collaboration**, of which having difficulty to set goals together, setting up a right framework by management, communicating implicitly and having to spend personal time on collaboration efforts are parts of. This takes place on the *collaboration* and *organisation level*.
- **Few opportunities**, which entails fewer hiring practices, education, and publishing opportunities. This takes place on the *organisation* and *academic field level*.

	Collaboration	Organisation	Academic Field
Not prioritising learning behaviour	• Do not prioritise collaboration themselves	• Collaborative work is not prioritised in set up	• In the academic field there is a large pull towards individuality
Non efficient collaboration	• Communication and collaboration takes more time than necessary • Often implicit communication	• Having to spend personal time on collaboration efforts	
Few opportunities		• Few education and job opportunities	• Relatively few publishing opportunities

Table 11: Overview of themes of issues, categorised per level.

5.5 C. How is help by the TU Delft viewed by participants?

Help suggested by the participants in the interviews are all answers to problems they also described earlier in the interviews. This means that all the topics described in C are covered in the interpretations section above. The issues described are all grouped on the different levels of the results, as described (Figure 36).

Figure 36: Overview of opportunities found on the different levels in the results.

6. DESIGN

6.1 Methodology

The results of this research will be used to generate a conversation amongst people who facilitate integrated multidisciplinary collaborations in one way or another. The goal is to grow awareness of the subject and to stimulate the right people to think about ideas to improve issues raised in the research. In preparation, it was discussed what information should be present and how to make this legible and understandable in a way that encourages the target group to think of ideas that could help. The poster will be redesigned after collecting feedback and then validated by talking to the Recognition and Rewards department.

6.2 Boundary conditions

Target group

The target group will be people facilitating integrated multidisciplinary collaborations. This happens on different levels where there are people who are able to influence things:

- The people inside the collaboration who are facilitating their own work,
- The people who facilitate multiple collaborations, such as faculties, department heads within faculties, cross-faculty departments etc.
- The people who organise policy and structure on the broader level of the university.

Being the people who will have to make sure that the solutions are actually implemented, thinking of the solution themselves will also give them ownership of the solution. This helps in the motivation to make sure the solutions are really carried out.

The target group consists of often busy technical people, who possibly do not want to spend a lot of time on something like this. They realise it is important, but so are many other things they have to do. Also, technical people are often a bit put off by doing something outside of their comfort zone. Having them do something funny or playing a unknown game can make it difficult for them to think and speak freely and really engage.

The goal of the design

This research aims to provide support to responsible facilitators in recognizing the issues raised, and stimulate them to enhance multidisciplinary collaborations.

The target group will be stimulated to think of solutions instead of coming up with solutions for the issues within this study myself. These people are best equipped to evaluate what is feasible within their particular environment and circumstances. The goal of this design is not to just hand over knowledge but to invite them to identify issues relevant to them and think about ideas to improve on these issues. To achieve this goal two things are important: making sure the design is actually used and making sure the target group comes up with concrete solutions.

The core information of the design are the findings with which the university could help (Figure 36).

Design of requirements

When looking into design requirements, there was a long list of requirements that could be used (Figure 37).

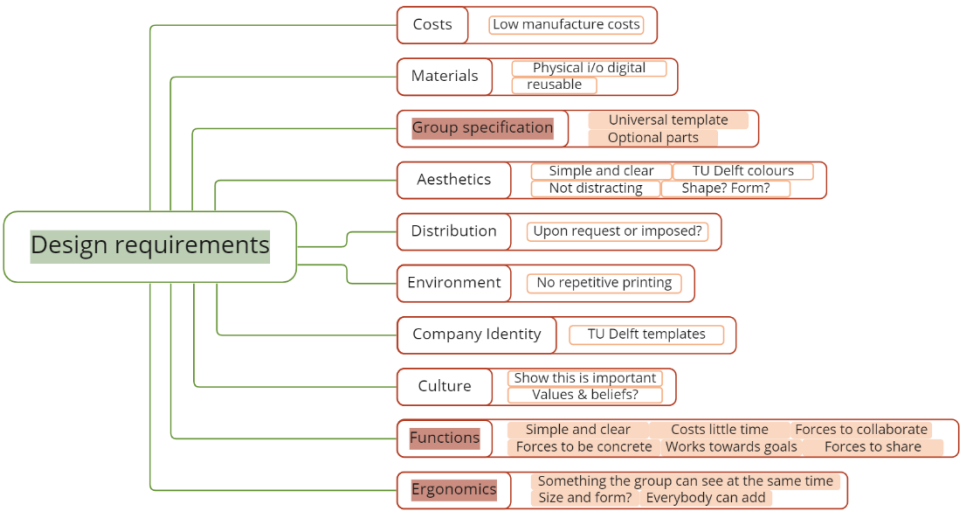


Figure 37: Overview of design requirements with focus highlighted.

A choice was made to focus on just three of the researched design requirements options: group specification, functions and ergonomics. These three were chosen because they form a combination of providing the most options and being important for the final outcome.

These options were then explored further and separated into requirements and wishes (Figure 38). Some are highlighted to show the additional specifications.

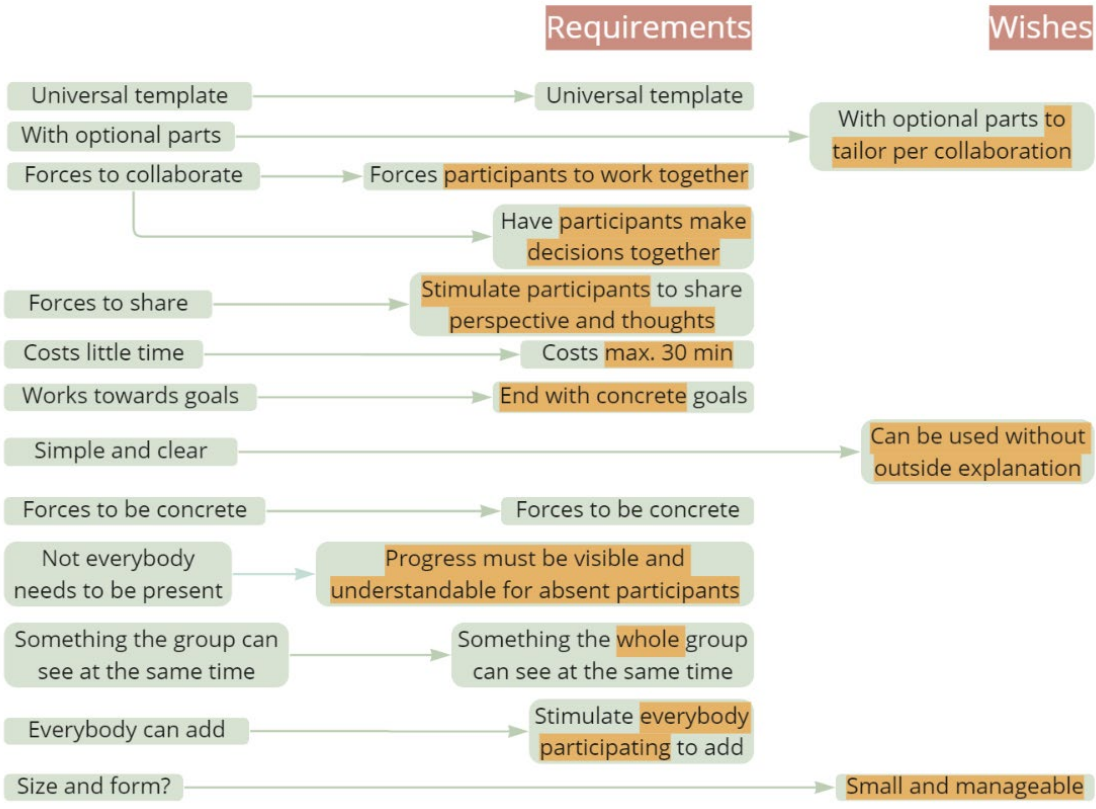


Figure 38: Requirements and wishes for the design.

Stimulating creativity

Users should be encouraged to be creative and think outside of the box. According to Wallas (1926) creativity begins with open problems, and then goes through four stages:

1. Preparation, in which the problem is investigated.
2. Incubation, in which the problem solver is not actively thinking about the problem.
3. Illumination, in which the better ideas come up, often suddenly.
4. Verification, in which the ideas are validated for their value.

It is noteworthy that these stages are not the same in size or effort whatsoever.

There are other steps added later in literature, but these four are still the steps most used and will therefore be used as a guideline for solution finding (Sadler-Smith, 2015).

Solution-focused approach

Solution-focused approach finds its basis in psychophysiology, in work done by therapists in the twentieth century (Visser, 2013). The idea is that, when asking the right questions, the participant finds the answers themselves. It requires solution focused listening, in which you give autonomy and help people open up.

6.3 Options for format

Poster option

The solution can be presented as a poster, a tool which provides handles for the conversation. In this case the discussion will need to be facilitated. The poster would be A3 size for practical reasons, to make it as large as possible while keeping it feasible for everyone at the TU Delft to print it.

First, the goal is to stimulate thinking about new ideas, rather than simply giving information. The text and the way the text is positioned on the poster should adhere to this. This can be done with open questions instead of examples of solutions. For example: “How are you going to make sure people prioritise team learning behaviour more?”

Although no solutions will be given, certain tips can be included, such as who they can talk about it with.

Serious game option

Another option is to create a game that can be played by the target groups with a facilitator to come up with ideas for solutions to the issues raised. Gamification is a method which uses game elements and play for non-entertainment purposes (Deterding et al., 2011). In such a game, all four stages of creativity can be gone through with the target group.

Instead of creating competition between the people playing the game, engagement and motivation could be created through storytelling. A story could be constructed, confronting the group with a situation in which they encounter an issue raised in this research. It should support them in finding a solution within the given options. A type of ‘hero’s journey’. (After a lecture of Marvin Soutanto, 2020)

Figure 39: Gamer motivation model by Quantic Foundry (Yee, 2016).

Quantic Foundry researched motivations for different gamers and such a game would very much focus on the Creativity player type, focusing on exploration and experimenting, together with customisation and designing solutions (Yee, 2016).

6.4 Choosing between options

To compare these options, a Harris profile is made (Table 12), in which the strengths and weaknesses of the options are compared (Harris, 1961). A list is made of the important requirements and each option is scored from -2 to 2 based for how well it fulfils that requirement (Roozenburg & Eekels, 1995). This score is then multiplied by the weight given to the importance of that requirement. The option with the highest score is the most suitable.

Criteria	weight from 1-10	Poster				Serious game			
		-2	-1	+1	+2	-2	-1	+1	+2
End with concrete goals	9								
Forces to be concrete	9								
Have participants make decisions together	9								
Stimulate participants to share perspective and thoughts	8								
Costs max. 30 min	7								
Universal template	7								
Forces participants to work together	7								
Something the whole group can see at the same time	7								
Progress must be visible and understandable for absent participants	6								
Stimulate everybody participating to add	5								
Can be used without outside explanation	5								
Small and manageable	4								
With optional parts to tailor per collaboration	3								
	score	53				30			

Table 12: Harris Profile comparing both options.

In the end, the poster will be further explored as a concept, but the serious game has high potential as some important criteria are very positive, such as being concrete and having participants make decisions together. This could be looked into in further research.

6.5 Constructing the final design

The final design will be based on the requirements and the goal set in the beginning of this chapter: stimulating people to think of solutions to the issues raised in this research.

The title

The title on the poster (Figure 40) should grab the attention. Therefore it was made the largest part, legible from a fair distance. The title was put as a question because this was thought to capture the attention better. The 'you' in the title is made bold, to make the reader feel more addressed.

Figure 40: The title on the poster.

The *integrated multidisciplinary collaborations* is highlighted with an asterisk because this is a term made for this thesis, and the readers may not know it. At the bottom of the poster the definition is explained using terms as multidisciplinary, interdisciplinary and transdisciplinary supported by self-drawn images (see Figure 41).

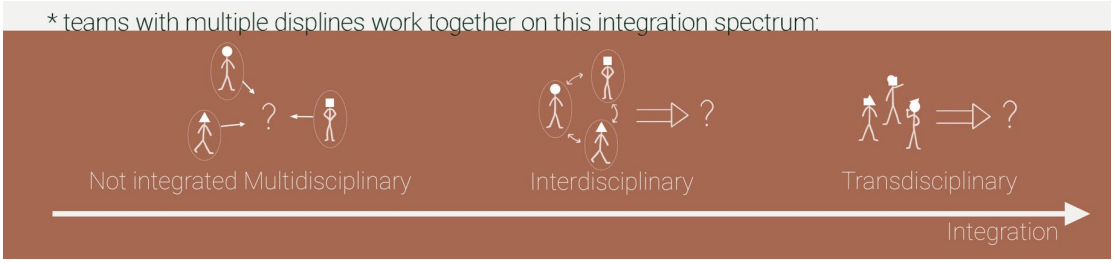


Figure 41: Explanation of 'integrated multidisciplinary collaborations' at the bottom of the poster.

Different target groups

The poster is made for different target groups as described at the beginning of this chapter. Therefore a distinction was made on the poster to indicate for whom specific questions are meant. After the title of the poster, the first thing the reader sees is "I could influence:" and then different headings are found: 'collaboration', 'organisation' and 'academic field'. This way, each target group will go to the right questions (Figure 42).

Figure 42: A divide per target group on the poster.

It is thought that although not all questions are applicable to all readers, it is still very useful to see the complete overview. That way, it is clear that all questions are addressed, that nothing is missed, what is in play on another level. It is made clear that everything influences everything on every level, including what the target groups themselves are doing.

Asking questions

The main information on the poster concerns the issues raised in this research, but framed in such a way that it challenges the reader to answer the questions posed. The issues are summarized in the figure below (Figure 43).

Figure 43: Overview of the issues raised in this research, divided over the three levels collaboration, organisation, and academic field.

The questions were all reformulated to start with ‘how to’ and to end in three dots with a dotted line underneath in which mentally or physically answers can be put down, as shown in Figure 44.

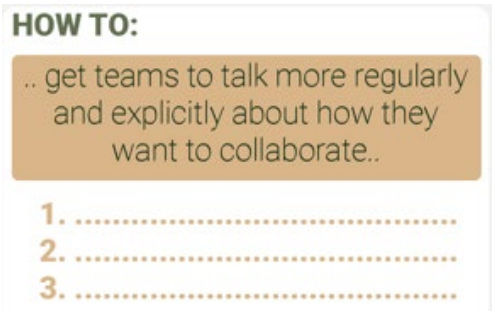


Figure 44: An example of a question on the poster.

Colour scheme

An extensive search on the internet showed different colour schemes suitable for a poster in a work environment. Calm colours and no big contrasts should be used, in my opinion. Two colour schemes from Adobe for posters at the workplace were eventually used.

Clear headings to guide the reader and an attempt at fewer text and more images were advised. It is difficult to keep the text to a minimum, because of the variety of questions that need to be asked. Therefore, in the explanation of the integrated multidisciplinary collaborations, images were added instead of the text.

Different colour schemes were tried out, and the depicted most right was eventually chosen as the optimal combination of legibility and putting attention to the right things.

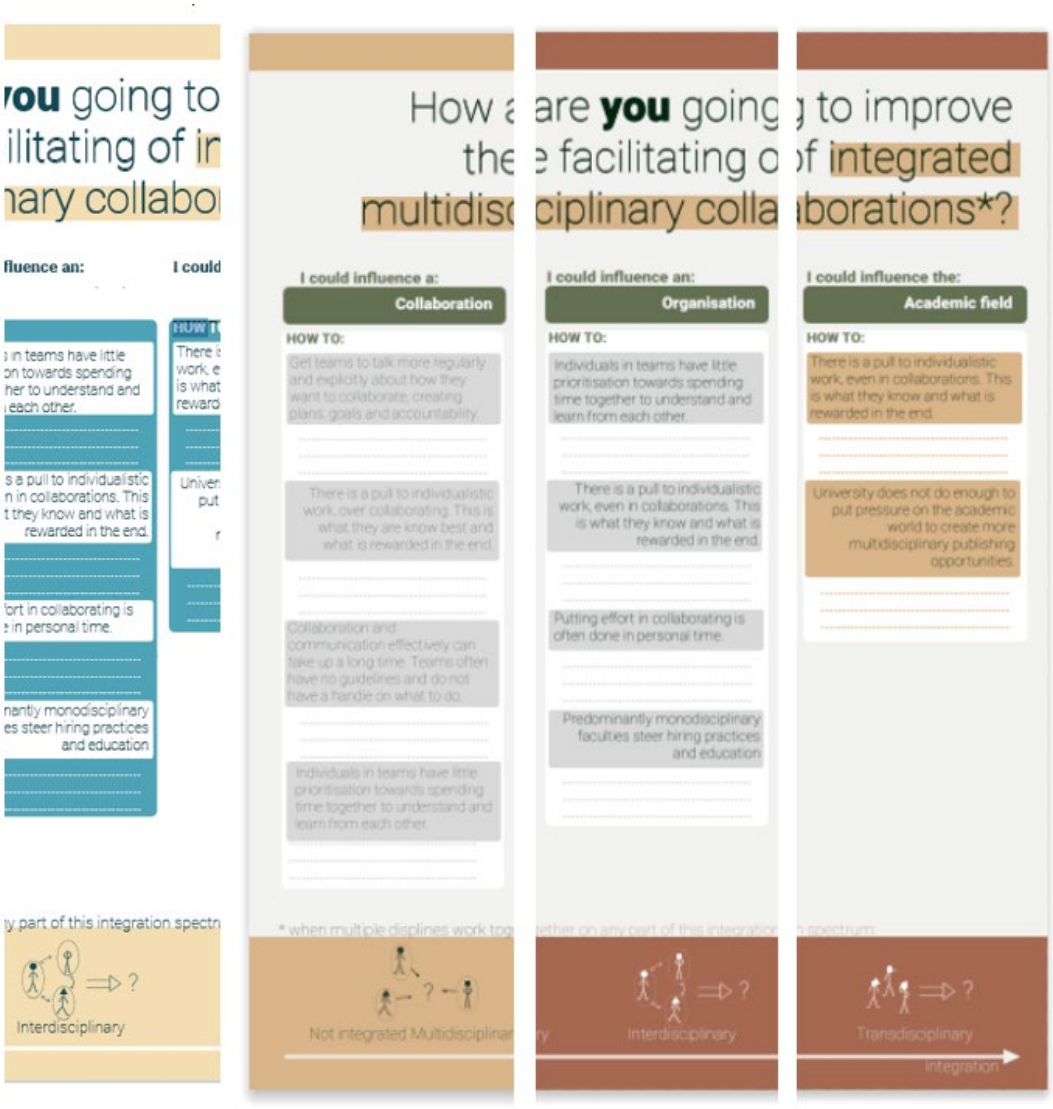


Figure 45: Different colour schemes as options for the final poster.

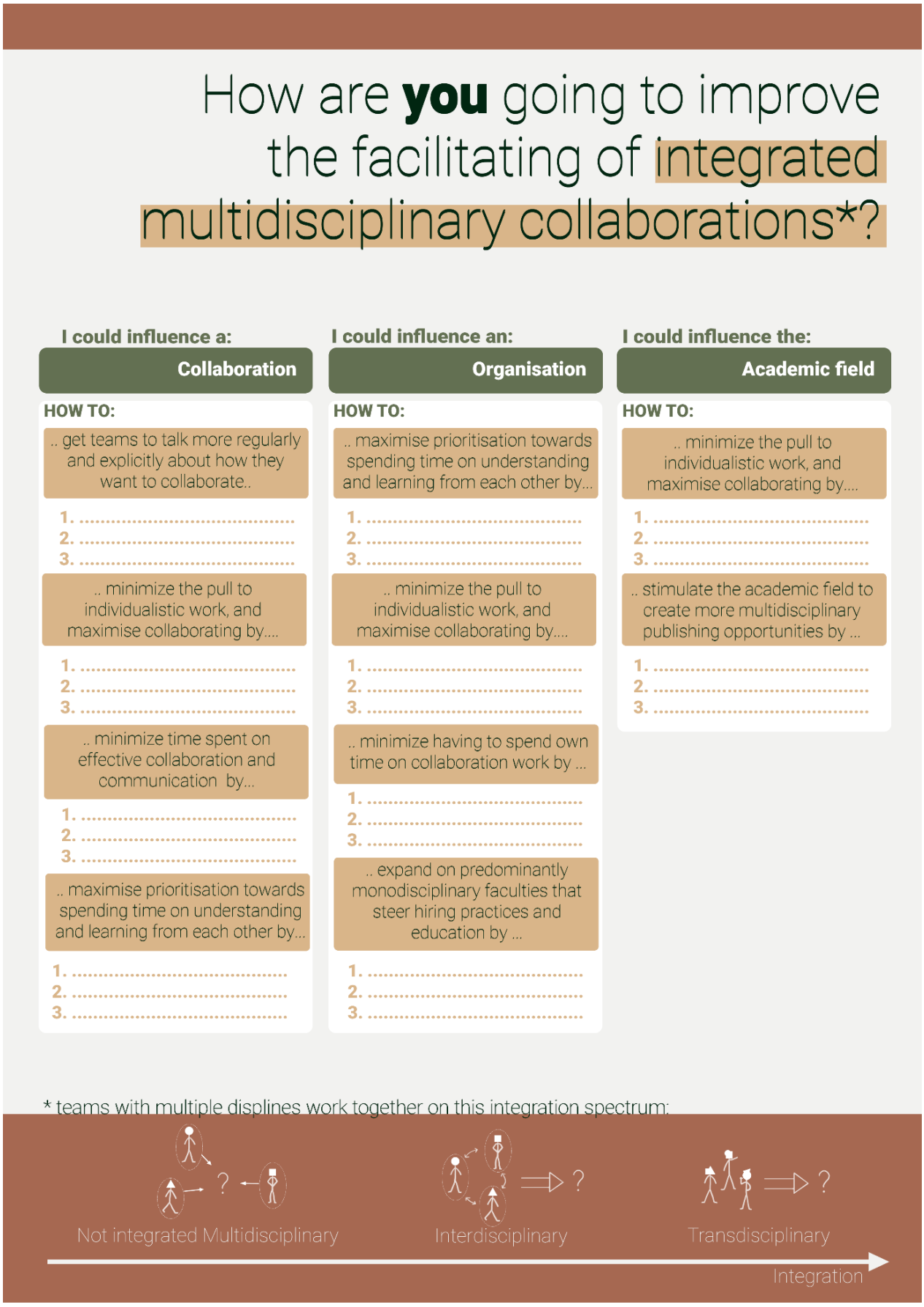


Figure 46: Final design first version.

6.6 Feedback and iteration on poster

This poster was shown to several people for feedback. Two of them are Industrial Design Engineering master's degree students who are experienced in designing similar tools. The poster was also presented to my supervisors, to two fellow CDI master students and to two colleagues from the Reward and Recognition department. Also, an expert group facilitator, who runs a company that facilitates meetings and discussions, helped to optimise the structure. Their feedback was collected and used to design a new version.

Feedback text

On the poster the sentences begin and end with dots, this was originally done to have the reader continue their thought. However, feedback mentioned that the sentences were hard to read because of the dots. Sometimes making rereading necessary. An idea to fix this is to rotate the poster to horizontally, which creates more space for the sentences.

Double questions should be taken out, where possible. They were there, because they are for multiple target groups to answer. Different ways of dividing the target at the start of the poster so they answer the right questions could be found, so that they can use the same text.

Another point of feedback was that the questions can be interpreted in different ways. For example, *'minimise time spent on effective collaboration'* can also mean stop collaborating. This needs to be reformulated. Furthermore, most people using these texts will be technical academics from the TU Delft. The terms *'maximise'* and *'minimise'* also are used in jargon in their fields. This might cause unintentional associations with the wrong things. Other wording such as '*create a balance'* or *´prioritise'* could be used instead.

To create a greater feeling of involvement, the words *our* collaboration or *our* organisation could be used instead of *a* collaboration or *an* organisation.

Feedback visuals and structure

The small images at the bottom of the poster were still somewhat unclear. It was recommended to add a short textual explanation and make the drawing clearer.

It was also pointed out that one of the requirements was to use TU Delft house style, for unity and so people using it, who work at the TU Delft, will feel connected.

When looking at the structure with the expert group facilitator mentioned above, she said that I am trying to do too much on a single poster. The poster should give the different target groups the right information, explain the purpose and concepts, and try to get them to come up with ideas and practical goals. She also explained, that when doing a session like this, you have session materials. These can be multiple posters, worksheets etc. I decided that the different goals I had for the design would be better served by different session materials instead of just the one poster.

Another tip to stimulate the target group to fill in the dotted lines, was to make it look less neat and finished, a bit more like a sketch or drawing. The expert group facilitator said that when something looks less perfect, people are more inclined to keep working on it and write on it.

Iteration of design

A new iteration of design was made to process the feedback given. Two posters and three worksheets were made as session material.

Explanation to the target group

For an explanation poster (Figure 47), a horizontal A3 was used. Positioning this horizontally would enable the people in the session to all look at the poster more easily when they are standing around it.

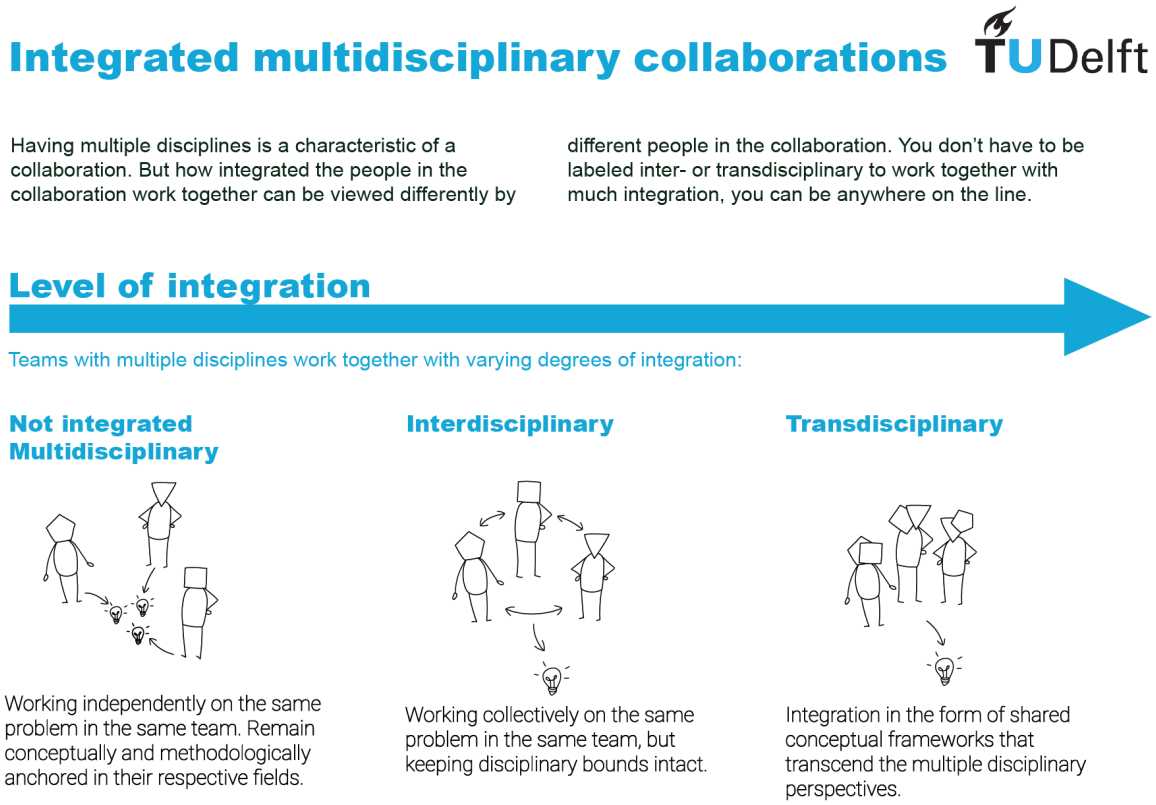


Figure 47: First poster of iterated session material.

The goal of this poster is mainly to get the target group behind the idea of more fluidity for integrated multidisciplinary collaborations. This is so they will not get stuck in preconceived ideas of terms they already know and to prevent that they will not come up with have an idea about what it should be too soon.

Dividing target groups

The next step in the session is to decide which issues they will generate ideas for. This is done in a poster (Figure 48) where they are given the three options and some explanation to help them choose what they can influence. Another A3 poster is used for this. The colours on the poster used are secondary colours of the TU Delft and these colours correspond with the worksheet they will use in the next step of the session.

Figure 48: Second poster of the session material in which the target groups are divided.

Worksheet per target group

The final session material is a worksheet to be filled out by the target group. In the first step of this poster, they can fill out together where they first come up with ideas (Figure 49).

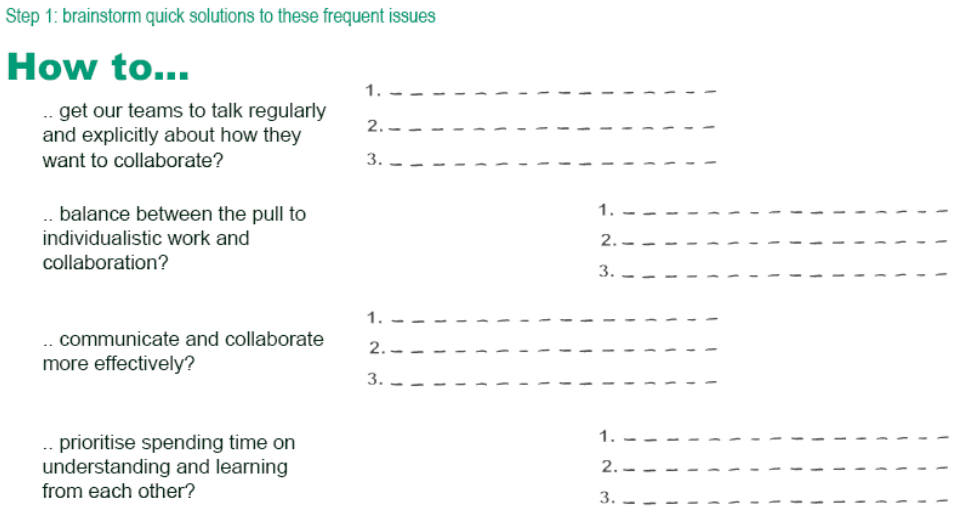


Figure 49: Upper part of the third poster of the session material for the target groups collaboration.

They then choose their favourite ideas for different issues and split up into smaller groups and expand on these ideas for the second part of the worksheet (Figure 50).

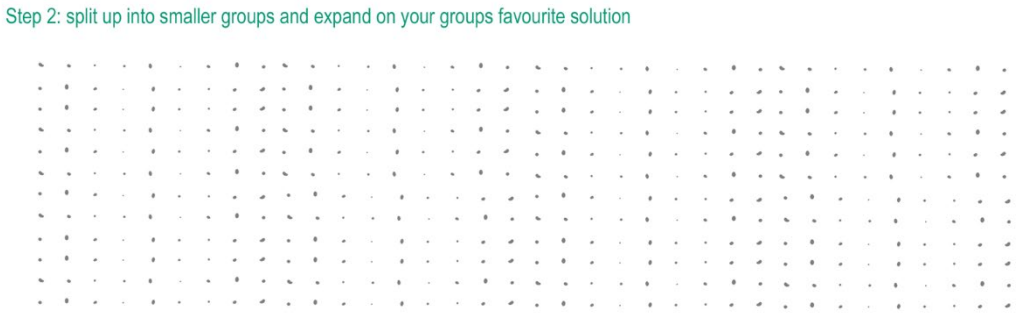


Figure 50: Middle part of the third poster of the session material for the target group collaboration.

In the third and last step, they have to write down action points for different time periods to make sure these ideas are actually used (Figure 51).

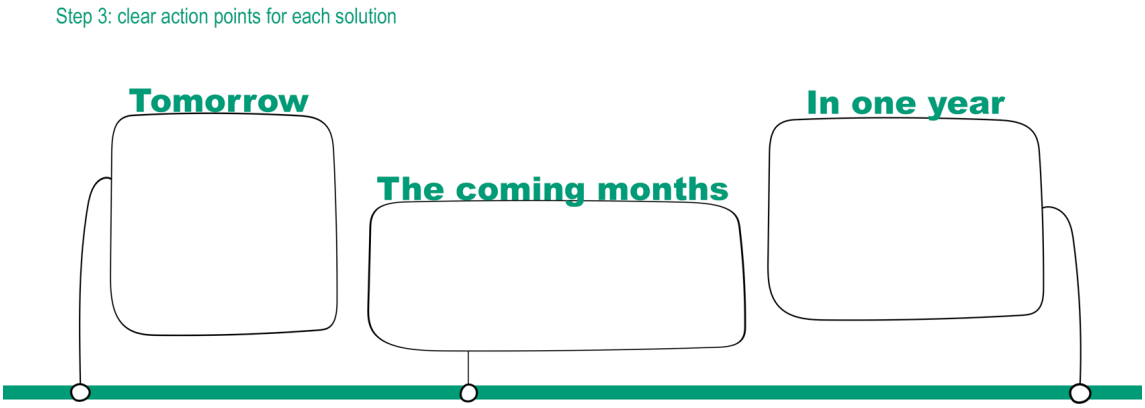


Figure 51: Lower part of the third poster of the session material for the target group collaboration.

The three worksheets have the corresponding colours as the second poster.

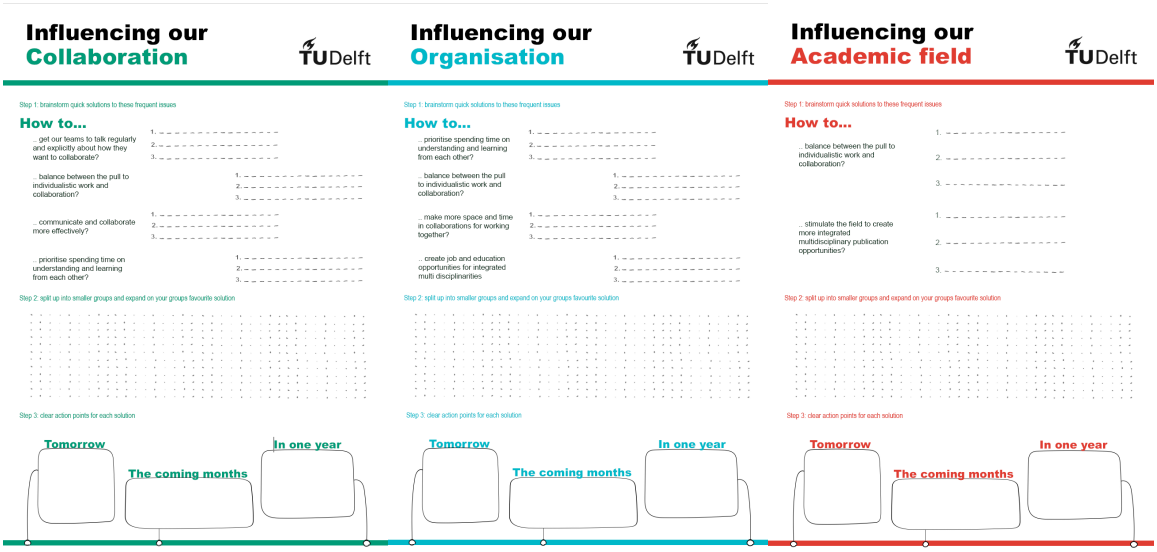


Figure 52: Three worksheets for the three levels of target groups.

The worksheets are also found in A4 size in Appendix E.

6.7 Validation amongst employees of Recognition and Rewards

As an ending of the project at Recognition and Rewards, this session was held with colleagues after giving them a presentation of what the research was about.

During this session, the participants were observed to see what worked and what did not. In the end there was also a moment where these improvement points were discussed with the participants to see what their experience was, if they agree and would want to add something.

The explanation and start were a bit difficult. This was thought to be because the participants were not the target group and needed to get in the subject. Also it was thought that every start can be a bit difficult. Within a couple of minutes people got to work productively.

A couple of materials are needed for these sessions:

- Pens or pencils
- Printed out posters
- Post-its

In the first step the participants had to read the questions, this was sometimes difficult. Then one person was holding the pen, and this acted as a sort of filter to which ideas were written down. A solution for this could be giving people post-its and letting them all write on a post-it and stick it on the poster that would be hanging on the wall in front of them.

Step 1 says: “brainstorm quick solutions…” this can be interpreted as *brainstorm quickly* or that the solutions they come up with should work on short term. This ambiguity should be taken out of the description.

Step 2 says to split up into groups. When the participants do this, they run into the issue that there is only one worksheet they are working on. It would be a good idea to print out separate work sheets for step 2 and 3 that the split-up groups can work on.

All participants really liked that they were forced to think practically in step 3. The thing that was left now after step 3 is what to do with these action points. Adding a small box of who is responsible for these action points or who to contact for them would be nice for this last step. Another thought is to add tear-off pieces of paper to the bottom of step 3 so that the people responsible can take home the action points.

In the end the small groups presented their solutions and action points to each other. It was discussed that it should be taken into account that if there are fewer small groups than there are issues on the poster, the session could be done again. Otherwise, some issues are skipped over. Definitely the group should end the session with an agreement on when to reconvene to discuss progress on the action points.

The last factor was timing. A plan was made to do this session in 30 minutes. Although throughout the session they were told the planning and when to move on to the next step, the whole session took about 40 minutes. It would be ideal if the planning could be moved up to 60 minutes. This way the participants have more time to think of ideas and the session will not go over time.

Other than theses points, the session went very well. The participants were all very enthusiastic and came up with good ideas they want to send on to people influencing collaborations. I took this as that the rest of the setup of the session was successful.

Final design

To get to a final design that can be taken into use, the concept needs to be validated amongst the target group and iterated to the feedback they gave.

7. CONCLUSION

7.1 The adapted Dynamic Collaboration Model

What factors can be derived from literature that have an influence on team learning behaviour in collaborations with multiple disciplines?

A lot of different factors can be found in literature on this subject. An overview was made of these factors and their relations (Figure 19). A focus was put on more contextual factors, the antecedents, ending up with all antecedent factors grouped in six themes: *Psychological Safety*, *Time, Setting Up Goals Together, Management, Formal Rules And Hierarchy, Reward System*.

7.2 Perception of team learning behaviour

How do individual people working in academic teams consisting of multiple disciplines at the TU Delft perceive their current team learning behaviour and what do they think about different factors that arose from literature that influence that team learning behaviour in their current collaborations?

It turns out, participants viewed their team learning behaviour generally as good, but they wanted it to be better. They described they wanted to be more involved with their team learning behaviour effort and to work together in a more integrated manner, when presented with the spectrum defined in Figure 7.

When talking about specific influence factors in chapter 6.2. B, *time* and *priority* is often not spent on the team learning behaviour effort and here is room for improvement. Just as with setting goals together and management. These are the factors named when asked about what factors are most important and where there is most room for improvement. Lastly, there were some contradictory statements made about the reward system. Some described it as a learning booster, some as a learning drainer. This is most likely due to two different reasons. The first is the fact that the current reward system is not inclusive for all types of work and efforts done. The second is the fact that the participants talk about the reward system on different levels. Within their collaboration they want attention for their work from their colleagues, which they often think to be okay. Within the university, they want less negative repercussions for integrated multidisciplinary collaborations. This is also applicable to the entire academic landscape, which is now set-up in a way that is counterproductive for people to choose working in integrated multidisciplinary collaborations.

7.3 Stimulation of team learning behaviour by the TU Delft

What do individual people working in academic collaborations consisting of multiple disciplines at the TU Delft think about getting help with or stimulation from the university for this team learning behaviour within their collaboration?

The answer to this question varies heavily among participants. Some did not saw any opportunities for help. Some had concrete solutions linked to the discussed influence factors. Others had completely new suggestions not linked to the interviews such as teaching collaboration skills. There were also some suggestions on how their team learning behaviour could be positively influenced by changes in the bigger academic landscape with which the TU Delft could help. This creates three levels on which help was suggested (see Figure 53).

Figure 53: Overview of opportunities suggested by participants.

7.4 Solutions

What can be done with the results so that change is solicited?

It was decided that solutions to the issues raised were best thought of by the facilitators of the integrated multidisciplinary teams at the TU Delft on the different levels:

1. Collaboration
2. Organisation
3. Academic field

The facilitators of the collaborations would know the best what the limitations and boundary conditions are for that specific problem. Thinking of the solution themselves will also give them ownership of the solution, which helps with making sure the solutions are implemented.

Thus, the team learning behaviour in integrated multidisciplinary teams at the TU Delft is most helped by something that incites this target group to think about ideas to solve these issues. This would help more, then choosing a singular issue raised in the analysis and design a tool for that. A session with session material was designed as a resource to help with thinking of ideas to stimulate team learning behaviour in integrated multidisciplinary collaborations at the TU Delft.

8. DISCUSSION

In this last chapter it is explored how different subjects had an effect on the process and outcomes of this research. In the end, there is reflected on what next steps would be for research in this direction.

8.1 Working for the R&R department of the TU Delft

This thesis was done as deepening research for the *Recognition and Rewards programme, project 11: Creating and developing high performing TU Delft teams*. It was clarified before starting, that this research would be independent and thus not steered by the department whatsoever. The Recognition and Rewards programme was only kept up to date on a weekly basis. Occasionally they helped brainstorming when the direction to go in was unclear, especially at the very beginning. Although clarified and agreed upon at the start they would not steer the research, it might have had an influence, still. By talking regularly with them, some of their interests could have become a focus of this research, because these subjects were brought to my attention.

The Recognition and Rewards programme is part of the HR department of the TU Delft. It could have been possible that the participants of the interviews, who are all employees of the TU Delft, did not always feel free to speak out of fear for their work. It is thought that this was not the case because of the numerous items of criticism voiced in each of the interviews.

8.2 Reflecting on validity of methods

To our knowledge there were no comparable social scientific studies done at the TU Delft on influence factors in (integrated) multidisciplinary collaborations. This makes it difficult to compare its findings with others. In the coming paragraphs I will reflect on the validity about a number of methods and subjects.

Literature review and the adapted DCM

This research was started with the concept of team learning behaviour. A description of team learning behaviour was chosen that focussed on the more visible, practical side of team learning behaviour. This starting point has steered the rest of the literature review mainly in looking for influence factors and the relationships between them. Possibly, if a different definition was chosen, it could have sparked other ideas of what to look for in influence factors and their relations.

A systematic literature review was not performed, and the resulting diagram cannot be seen as complete. Instead, the overview is based on a pre-existing review on learning boosters and drainers by Elzer (2021). His literature was checked to see if they were indeed general learning boosters and drainers, and not specified in a hospital setting where his research took place. This was the case for all but one source. The findings from this source were separately checked in literature. After this, new literature was searched that built upon the literature of Elzer. This is also where discrepancies could have been detected if the research was not performed well.

Other influence factors mentioned in the model of work-team-learning by (Edmondson, 1999), and the factors researched in Kim et al. (2020) were also used. The ensuing research was based on terms already found in these previous researches, possibly making it a narrower search than if these researches were not used as starting point. Next to the literature found, there were also relations established that deemed logical, but was not found in a literary source. Nonetheless an overview was established and categorized to be as clear as possible.

The following choice that influenced the adapted DCM is that the main focus of this research is team learning behaviour, around which influence factors and their relations were found. As said, this overview is not complete. It would be interesting to see what other influence factors are found, if a different key factor of integrated multidisciplinary collaborations is chosen as centre point.

Focus on antecedents

After the setup of the living adapted model (Figure 19), a choice is made to focus on antecedents. As these are more context factors as opposed to internal human factors, they are simpler for the university to influence. A different choice could also have been made, to focus on input or on how to stimulate the process itself, but the antecedents fitted the research question the best.

Interviews and their analysis

Choosing the participants for the interviews started of quite structured, taking variables like collaboration size, phase of collaboration and types of disciplines into account. But when it turned out to be quite difficult to get these people as participants for the interviews, these requirements were loosened. After getting two or three participants, the rest were found mostly through referrals of previous participants. This could have influenced the research. For example, certain communities could have been skipped over because the participants did not know them. Or only people could have been spoken to that are known for being in a multidisciplinary collaboration. However, it is assumed that quite a broad selection of people was involved, as participants came from all eight faculties of the TU Delft.

The semi-structured interviews are also one of the things that make reliability of this research across time difficult. The answers given in the interviews would vary because they could be dependent on many things such as their mood, or a bad week. Also, if something has changed in the meantime in their collaboration or in the broader academic landscape, answers would most likely also change. This is however always the case with semi-structured interviews. Because of the free character of this method which allowed to ask about other subjects coming up, it was decided that this was the best method for this research.

Some of the interviews were done online and some offline. It was noticed that online interviews were each noticeably shorter than the interviews offline. Online, answers are shorter, and interesting details might have been missed.

Reliability across the interviewer is also difficult to ensure for future research. As the interviews are semi-structured, the interviewer will ask further questions about interesting comments made. This is of course subjective as to what comments are interesting to continue questioning about.

The influence factors gotten out of literature, which were checked to be learning booster or drainers with the participants, did match for five out of six.
This suggests a high level of validity of construct.

During the analysis of the data, the quotes used, are chosen by the author, this allows for a subjective addition to this research.

Validity of concept

The concept was made in the last phase of this thesis. The next step necessary is to validate the concept amongst the real target. This could be done by revisiting the participants of the interviews. However, it would be even more interesting if new participants could be found, who have not thought about this subject very thoroughly yet. This is important because the target audience for the poster would also have not done this. After this phase, group sessions could be

held with the actual target group to see what ideas and solutions they come up with and new meetings can be planned at that moment. In the end it should be monitored for a longer time if these actions are actually undertaken.

8.3 Negative perspective on an influence factor

The participants perception of the reward system is contradictory. It is seen by some a learning booster and by others as a learning drainer. Those people who think it is a learning drainer experience negative effects of the reward system. On the other hand, it could be implied that people also have a bad experience with *setting up goals together* and *management.* These factors are named as relatively important and as the factor where they have the most room for improvement. What could be the difference between these factors and the reward system, making the reward system unclear and the other two not?

It could be that they don't have a positive experience of *setting up goals together* and *management* now, but they can envision how much better it can be. As opposed to with the reward system, they do not only have a non-successful experience, they actually have negative repercussions now. This might be why it is seen as a learning drainer instead of a potential booster.

Another possibility could be that the reward system is very different in the academic field compared to industry looked at in literature. The reward system in the academic field is known for not including everyone at the moment. This is why a department such as Recognition and Rewards is formed.

8.4 Looking forward

How useful is the end product?

The usefulness of the final design can only be determined by means of validation by the target group, but it looks promising after a pre-test with other people. If the goal of the final design is reached, this could help collaborations to tackle issues raised in this research.
The approach of integrated multidisciplinary collaborations instead of the terms inter- and transdisciplinary collaborations could be practically useful. This could help groups when discussing what their goals are for working together, where on the line they would want to be.

Significance for the CDI department

This research is built on previous research of the CDI department, both previous theses and other research. Therefore, it is deeply rooted in the CDI department at the TU Delft. In turn, this thesis is also be significant for the CDI department at the TU Delft, because it investigates a broader perspective of the relations between many factors that are often researched. The fact that it is researched amongst integrated multidisciplinary collaborations at the TU Delft, gives the CDI department insights into the system they work and often do research in.

Recommendations for next steps and future research

After this thesis, one thing really needs to be done still to fully complete this research. As said before: the concept still needs to be validated and preferably iterated upon.

But, also other ideas for future research are mentioned. The other themes, Input, Process, and Output can be researched next to just Antecedents to see if new perspectives arise. But also, this research could be done on other focus points than learning behaviour, for example effective communication, or innovation. This would make for a very interesting shift in the living adapted model.

Future research could also focus on designing and developing more practical solutions to specific issues raised at the TU Delft.

8.5 Personal learning experience

The subject of the research continued to be interesting the whole time during the thesis. I really liked the practical aspect, speaking to people who work at the university where I also walk around every day.
However, performing academic research by myself was very difficult for me. As I started during a lockdown due to corona, I had to work from home and did not know anyone who was doing their thesis to talk about issues or anything. This got better after the lockdown ended and I started working in an environment where several people from CDI were working on their thesis. I felt like I was learning a lot more there, because we would discuss topics that I did not quite understand or that I did not see the use of.

I have also been struggling with my mental health, all through the 12 months I was working on my thesis. As working on one's thesis is an inherently individual process, it was very difficult to keep myself motivated and working while I was struggling with a depression. This, in turn made doing my thesis a lot more difficult.

When looking back, things that I take with me are knowing how to keep going when things are not fun and difficult. To push through in a long project, deal with my own expectations and disappointments of setting goals and maybe not reaching them in the timespan you had in mind. To do this, for me it helped to not have a long-term planning which put pressure on me. Just keep showing up and doing work and regularly make a new short-term planning.

Looking forward, I now know even better the value I attach to working together with people on the same thing. Sharing goals and work gives me motivation and perseverance. I also value the people around me when I'm working. This is a very important factor for me when looking for a company where I want to work at. I also realised that continuing in academics is not really for me due to the research-oriented work instead of working on more practical products or with people who are producing something. The latter feels more interesting to me.

9. APPENDICES

Appendix A Empty consent form for interviews

Consent Form for interviews thesis Sarah Bennink Bolt

I have received information about the study, I have been able to ask questions about the study and my questions have been answered to my satisfaction.

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

I understand that taking part in the study involves participating in a semi-structured interview that will be recorded to retract data afterwards.

I understand that I will receive no direct benefit for the participation in this study and that the information I provide will be used for a suggested design to help collaboration at the TU Delft.

I understand that any personal information is collected about me that can identify me, [e.g. my name or where I live], will not be shared, will not be copied into the research and will be deleted after the thesis is done.

Date:

Autograph:

Appendix B Interview protocol

Welcome and thank you for doing this interview with me. How are you? I would like to start with giving you a little bit of background and after that we have to go through the informed consent form to start the interview.

As I said via email, I am doing my master thesis researching academic collaborations at the TU Delft. Specifically how people from different backgrounds learn from each other to innovate together. This is what we call group team learning behaviour. *(I will explain in further detail later on in the interview when we will talk about this).*
The goal is that after collecting all the data from the interviews, I will design a proposal to support this team learning behaviour in collaborations at the TU Delft.

The interview consist of multiple parts. In the first we will look at the collaboration you are in at the moment, then we will look at how you recognize team learning behaviour in this collaboration, and later on, I will ask you about what might influence this team learning behaviour.

Do you have any questions before we start?

- Informed consent form + tell them what happens with the data
- Get permission to record

A. Getting an idea of the situation

1. Within this interview, the idea is that you have one collaboration in your head that we take as a perspective to answer all questions from. Would you have an idea which collaboration this could be?
2. I am curious to how dependent you are of one another within your team. Where on this line would you place your collaboration? *(make sure this is clear on recording!)*

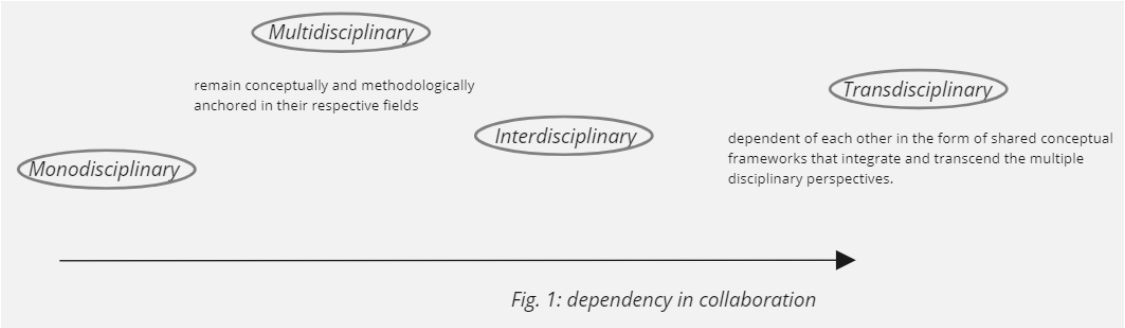


Fig. 1: dependency in collaboration

3. What is your own background and how does this differ from the people you work with in your team?
4. What is your common goal and what is your part in working towards this goal?
5. Do you talk about the way you (should) collaborate together in your team?

a. Reflective & planning? Is this easy or hard? Did this change over the course of time?

6. How do you feel you should be busy with this? More/less?

B. team learning behaviour

Within collaborations, I've looked specifically towards the concept of team learning behaviour. The main goal of team learning behaviour is gaining new knowledge and perspectives to improve plans and ideas. The type of actions you could recognize are:

- Asking questions
- Asking for feedback
- Exploring new ideas and experimenting
- Reflecting together on outcomes
- Talking about mistakes or unexpected results
- Agreeing on how to make knowledge concrete

To have team learning behaviour in a team specifically, assumptions and disagreements and these type of actions should be talked about openly.

1. Do you recognize any of these activities in your team? Are there other activities that you can think of, with which your team learns from each other?
2. Do you have agreements or systems to do or stimulate these activities? What is easy/hard?
3. What could help you with this in the future?

C. factors on team learning behaviour

The past months, I have found different factors in literature that have an influence on how well people are able to learn from each other in collaborations. Now I would like to ask people that really are in these circumstances if they agree and if this is the same at academic collaborations at the TU Delft.

So these 6 factors, I have printed out and I just wanted to make sure you understand what is meant by them. Do you have any questions about them? Just a reminder, because I record the interview we have to be mindful to say which factor we are talking about, instead of saying 'this one' so I can still understand it on the recording.

- Psychological safety
- Time
- Hierarchy and formal rules
- Setting up goals together
- Reward system
- Management

1. Can you tell me, for each of these six factors, if it is a factor that could influence team learning behaviour in your opinion? If so, would it have a positive or negative effect? I would like you to think out loud and explain why, so I can follow your thoughts.

Order of questions based on the order of the previous question:

a) Within your group, is the amount of **time** something that works for or against **team learning behaviour** at the moment? How/why?

b) Within your group, is the amount of **formal rules and/or hierarchy** something that works for or against **team learning behaviour** at the moment? How/why? *[Formal rules and hierarchy, communication norms]*

c) Within your group, is there a **reward system** and does that work for or against **team learning behaviour** at the moment? How/why? *[Reward system; funding, group rewards, for learning or for result.]*

d) Within your group, is the way **management works,** something that works for or against **team learning behaviour** at the moment? How/why? *[Good leadership traits and behaviours.]*

e) Within your group, is the way **goals are being set and thereout subgroups arise** something that works for or against **team learning behaviour** at the moment? How/why? *[Task interdependence, participatory goal setting, grouping, aligning interests.]*

f) Within your group, is the **Psychological safety** something that works for or against **team learning behaviour** at the moment? How/why? *[Psychological safety, relations and group dynamics.]*

2. Is there another factor that helps or hinders you?
3. Could you sort these factors on how much effect they have on team learning behaviour within your group? (*watch out for being unclear on recording)*
4. On which of these factors do you think there is a lot to gain still within your group to support team learning behaviour?
5. Would you want the TU Delft to help with this? Why/How?

D. How would you do it differently?

1. If you got to change something within your current group, what would that be?

If appropriate for the person because they are working inter- or transdisciplinary:
2. What makes collaborating different when being very dependent of each other? Is there something specific you have to watch out for?

E. Closing questions

1. Is there something we haven't talked about which you think is important?
2. Is there someone of which you think would be interesting for me to talk to?
3. Is it okay if I keep you posted of the research and as soon as I have designed something, I could run it by you for feedback?

Thank you very much for taking the time to talk to me about this. My planning is now to first finish the interviews, and get all the data out of them. I will make sure all this data stays anonymous.

Appendix C Signal words for coding

List with signal words of group 1, answering SQ2, grouped to answer research question 2: How do people working in academic teams consisting of multiple disciplines at the TU Delft experience team learning behaviour in their current collaborations?

Recognizing team learning behaviour		Recognize; they talk about one of the actions of team learning behaviour; this is when we learn the most;
Do you talk about how you collaborate	Explicit	I will talk to them about it; I made them discuss it; I say this out loud; We have moments for this;
	Implicit	Very spontaneous; we just show this; It just happens; it's not discussed; I have not thought about it;
What worked well		This worked well; this was really helpful; this goes easy; It is very clear; gives no issues;
What did not work well		This is difficult; for this we have to work really hard because we are not succeeding; Struggling; people don't want to do this; I would want it differently;
Are there systems or agreements		Meetings; something is planned; we always have/do… ; this is organised; scheduled; we agreed on..
Goal vs. reality		It doesn't work like that in real life; the plan was to… but now…; we want to be at a different stage; we are aiming to be..

List with signal words of group 2, answering SQ2, grouped to answer research question 2: What do people working in academic collaborations consisting of multiple disciplines at the TU Delft think about different factors that arise from literature that could possibly influence team learning behaviour in their current collaborations?

Management	Management; the leaders; leadership; project leader; the people who are in charge; the person who is managing;
Psychological safety	Psychological safety; I don't feel comfortable to..; I would rather not ask people; speaking freely;
Setting up goals together	Setting up goals together; planning the end goals together; We do not think about goals together;
Hierarchy and formal rules	Hierarchy; rules; formal rules; people higher up are seen as..;
Reward system	Rewards; funding; motivation; attention; career prospects;
Time	Time pressure; too much work; other things to do; people don't show up; cut short;
Other factors	Any of the other factors mentioned on the diagram.

What gets more important in TDC's	In TDC; when you are more dependent on each other; integrate;

List with signal words of group 3, answering SQ3, grouped to answer research question 3: If anything, what do people working in academic collaborations consisting of multiple disciplines at the TU Delft want to see changed to stimulate team learning behaviour in their current collaborations?

Are they content with the situation	Want to spent less/more time; I want it different..;
What would they want to see changed	*Is an open direct question*
Where do they think is room for improvement	This could go better; we need more money for this; we need more time for this; There is not enough of this;
Do they want help from the TU Delft?	TU Delft; They can have a role in this; within the faculty;

Appendix D Communication chart

Communication Chart

Problem theme	From Interviews		Intuition / Personal opinion	What is my Experience?	What does literature say	Important Insight	Creativity	Solution direction	Part of which sub RQ?
	non - managers	managers							
pull to individualism + time	"When my colleague got stuck in his progress for a few months, we stopped the weekly meetings." 12:8	"We constantly drift further apart ... [managers need to make sure] that they are brought back together and keep the connection" 3:58	You need an intervention if things stall.	people don't want to ask for help; or just don't think about it because you feel frustrated; feel like other people won't be able to help you/ you are the only person who can do this. ; CAUTION for burnout	UNREALISTIC EXPECTATIONS OF COMPLETE HARMONY AND EASE - create expectation management that collaboration and learning behavior takes more time Stokols, D., Misra, S., Moser, R. P., Hall, K. L., & Taylor, B. K. (2008). The Ecology of Team Science: Understanding Contextual Influences on Transdisciplinary Collaboration. American Journal of Preventive Medicine, 35(2), S96–S115. https://doi.org/10.1016/j.AMEPRE.2008.05.003	you need to manage expectations from the beginning. the more complex a collaboration is the more preparation and energy goes into making it work! (analogy of food / kimchi / recipies)	a sort of hand that pulls you back into the collaboration (and thus creates opportunity for learning)	expectation management; creating new habits	2 + 3
time	"Time is always a constraint" 4:18 "you need to have time to really work in a group together, and that is often a problem" 5:6 "the time to do meetings and explain and explore is very important as well" 12:52	"The less time we have, [the less learning behavior we tend to show" 6:29	Something small, you can add on to other activities, ALSO make people see this takes time if you want to do it right	you feel when there is little time, you want to save every minute, so you stop communicating and just create output. often not the best output.	[2;5;6] Stokols: prepare that they need to dictate considerable time towards establishing common ground	balance between : can you make collaborating cost less time & make people willing to invest time because they see the necessity.	something you always have on your desk to remind you; a short communication line, give people some extra time magically/ combine it?	intervention; valuing transdisciplinary learning behavior	2 + 3
time	*time is quite low on the importance ranking of everybody*	"time, I don't think we can do too much about it." 6:42	I can imagine they feel that way, because they often don't notice they are missing out on something if there is less time for learning behavior. too little time is just the way it is to them.	natural reaction of people on little time = less communication and less collaboration and therefor less learning behavior		stimulate healthy habits for collaboration and learning behavior instead of known and 'easy' route short term	long term gains vs short term feeling. [analogy: I'm hungry now, I want an easy unhealthy snack] / unhealthy habits. Maybe educate them, in a positive way: talk about benefits and tools	creating new habits; valuing transdisciplinary learning behavior	2 + 3
structure of the team	".. very spontaneous, if you have an issue, you go to someone" 1:47 "Its not actually discussed as much" 5:41 ".. it either happens or it doesn't" 5:42 "We don't talk that much [about it] actually, we just know because we worked together for 2-3 years already" 9:3	"nobody has come to me saying [it doesn't work], so I think that's a positive sign" 4:4 "never really consciously thought about it" 6:39 "It's not like we discussed it like this, it just evolved" 8:24	I feel as soon as people start talking about it, the biggest step is already taken. Make them think about it and discuss openly together.	people are not used to thinking about it, I think if you think/ talk explicitly about where and what learning behavior takes place... etc. as the Dutch saying goes: A clear structure gives room for adventure	teaming / organising to learn / work team learning	combination of 'we want to be a bit more busy with it' and 'it just happens' talking about how you want it to happen would be the best first step.	Give them structure to discuss learning behaviour, where & does this take place in the collaboration and what are the benefits of spending time on learning behavior? would be one/sometimes?	give them structure	2 + 4
	"Being more busy with it would be better" 1:44	"[the amount of time spend on learning behavior] is too little, way too little." 3:9	A lot will help with this.						
Making knowledge specific + skills + speaking different languages	"Standards of the [different] fields are different. So it is very hard to converge and make specific what it means in the end. So this we struggle with" 10:26 *also often stated as most room for improvement*	"When you make knowledge concrete, there is tension. You lose a little bit of the scope of the initial idea, because you go from conceptual to clearly defined to actually do something with it. This is a constant dilemma" 8:12 "The most difficult is getting the knowledge concrete, while everybody is content" 11:12	very tied to speaking different languages,	to do this together you learn each others language, not just disciplinary language but also personal. This takes time. ["2 years" 11:22] maybe a sort of dictionary, or tension cards (where the tensions lie) would help		speaking different languages within different disciplines is a barrier for learning from each other and there are certain moments in the process, when you make something specific that this becomes more apparent.	a tactile/ visual tool / form language [Anne Kamp] to help communicate, boundary objects to communicate across disciplines	intervention? / to use in specific situation	
setting up goals together + skills + speaking different languages	"setting goals together has the most positive influence on learning behavior" 2:44 "Setting goals together is really important in my experience" 4:36 "setting goals together becomes more important [when you work more integrated] because you need to understand and explain and reflect together" 12:56 *also often stated as most room for improvement*	"Setting goals together is the most important factor" 3:54 "Setting goals together, you have to compromise and be critical at the same time. ... that is very important." 8:47	I think, this could mostly be found important because this is the main time they have to communicate a lot and make things specific. But this is also where tension lies, [connected to making specific] and thus is found difficult.	people find it difficult but its also very fruitful.		When difficulties arise in learning behavior, such as making it concrete, people	make sure people don't avoid it because its difficult,	structure; use in specific situation	
structure + management	"good management sets up how the learning behavior works .. This is the most important factor" 5:17 & 5:49 "management should be directed to creating the environment that facilitates learning from each other" 7:15 "management is related to everything" 9:18	"management needs to give a good example of the culture" 3:22 "It's the job of the manager to connect people" 4:19 "Management is most important, that's where it starts" 11:56 *Is also often stated as most room for improvement*	I think management sets boundary conditions, space & time & psychological safety for learning behavior. Also people often look up to management, so you need to give a good example of showing learning behavior.	Management without strong hierarchy leads to more clarity about function [facilitation] because that's their main job, not 'being the boss'. possible: with more hierarchy, this is less clear, so open communication and a good example is more important.	function of management in conditions for learning behavior; goedheid verspreidt zich als een virus, sneeuwbal effect	it starts with management, dependent on the situation.	design something just for management, it always starts there. Or design something specific to talk to managers to ask for space and time for this.	use in specific situation / structure (for management) / toolbox	

reward system	"I wouldn't know a reward we want, well giving attention to people" 2:20 *authorship is a reward people want, which is difficult to share in multidisciplinarity* 9:15	"The reward system is [focused on] getting tenure or UHD" 3:19 "I don't care much about rewards, [just that something is acknowledged as mine]"4:30	more than logical people want to see positive feedback on what they do. And negative feedback, even not personal but in the infrastructure, works demotivating. In this case feedback is mostly attention and recognition / praise & a raise. Also feel like someone needs to look at the whole infrastructure more broadly, outside of the scope of this project.		noticed that this is slightly different than literature on commercial working environments.	people want to be seen and heard / praise and a raise.	practice positive feedback, as an assignment. make a very clear overview of what is expected in order to move up the ladder; including softskills.	creating new habits	
reward system + failing infrastructure	"In the interdisciplinary field, chances are, you're gonna be publishing at venues that are not going to benefit your career as long as your career trajectory is determined by your publication list and your H-index. No hard hitting publications, no matter how important everybody in both fields think you're work is. [So then you write about subjects in a way that brings you forward in your career]" 10:40	"The current scientific reward system contributes negatively to learning behavior and collaboration. The peer review system .. the publication system .. will shine light on incremental monodisciplinary work easier. [Here is so much room for improvement]" 11:28							OOS
rewards system	*is ranked low in importance*		I get the idea that people don't find this important because they say they can't think of ways a reward system would work. There is the possibility that something they can't fathom would work.	praise works to motivate					
mindset	"I think it is very important what type of people are in the group, [you need] really open minded people .. that they are not their for their own gain." 8:38	"I can see a lot of ambitions to cross disciplines, things like Convergence and such big initiatives, where I think [our collaborative] mindset could really help them to grow. But we never get a seat at the table there." 11:36 I would really love to see an exchange of knowledge [about meta-skills and methodology], so a little more abstract than a seminar" 11:54 "[For the TU Delft] I like the word collective memory, now everything is about the content of a project, but my neighbours don't know how we manage to learn from and use each other, and I don't want to put that added responsibility on the shoulders of my people" 11:55	maybe already works itself out, if you don't want to collaborate you often wouldn't be found in such an integrated collaboration. If not, than explaining and valuing transdisciplinary learning would be important to start with.		goedheid verspreidt zich als een virus, sneeuwbal effect; pay it forward : effort vs effect; synergy group growth mindset		would there be a way to	valuing transdisciplinary learning	
collective memory + skills			collaboration leads to more wanting to collaborate? make sure it does not become another separate island that people aren't finding when they need it, but actually connects the existing islands.	people who are struggling with something they want to do, are eager to know more about how they could do it (learning behaviour / collaboration)		people who are busy with how to learn from each other are eager to know more.	setting up a structure for the whole university, in which groups can join, presentations, seminars, sharing experiences about meta-skills and methods; pay it forward : effort vs effect.	structure	
Skills + struture	"Experience is provided in project based courses [during the BSc and the MSC] where they could learn these type of things, but the meta skills are not particularly taught" 9:25 "we are trying to work out how to work together and learn from each other and all the components of the scientific process [trial and error]" 10:24	"It's 2 different worlds that don't really understand each other and even if they have all the right intentions and motivations, they are not succeeding in collaborations and they don't understand why" 8:2	there is a knowledge gap in **practical** skills to tackle difficult moments within collaboration such as learning behaviour. Collective memory could help, but also needs influx of the right info. next to tools and structure; asking for help is very important. But you need to know where to ask for help.	people tend to give up if they notice it not working or giving the hoped outcomes. especially when you cannot identify where it's going wrong.	theory and practice are 2 different things. (although knowing how is a good first step)	• people need to understand the importance of eg. learning behaviour so that they don't give up • they need tools / structure to fall back on when they don't know what to do when something doesn't work.	toolbox?	valuing transdisciplinary learning; tool	

Integrated multidisciplinary collaborations

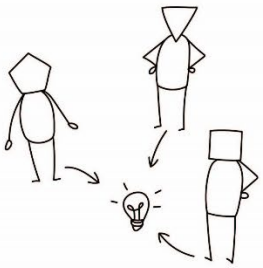
TU Delft

Having multiple disciplines is a characteristic of a collaboration. But how integrated the people in the collaboration work together can be viewed differently by different people in the collaboration. You don't have to be labeled inter- or transdisciplinary to work together with much integration, you can be anywhere on the line.

Level of integration

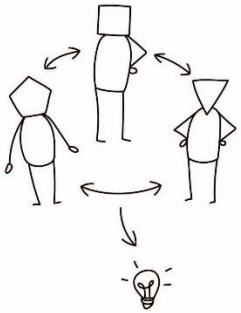
Teams with multiple disciplines work together with varying degrees of integration:

Not integrated Multidisciplinary



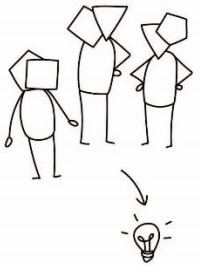
Working independently on the same problem in the same team. Remain conceptually and methodologically anchored in their respective fields.

Interdisciplinary



Working collectively on the same problem in the same team, but keeping disciplinary bounds intact.

Transdisciplinary



Integration in the form of shared conceptual frameworks that transcend the multiple disciplinary perspectives.

How can **you** influence **TU**Delft collaborations?

Collaboration

On collaboration level, you can influence goals, plans, actions and prioritisations. You can discuss in what way time is spent and how you want to work together.

Organisation

On organisation level, you can influence multiple teams by creating overarching visions and boundary conditions.

Academic field

On academic level, you could influence movements and exert pressure to help things change.

TUDelft

Influencing our Collaboration

TU Delft

Step 1: brainstorm quick solutions to these frequent issues

How to...

.. get our teams to talk regularly and explicitly about how they want to collaborate?

1. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
2. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
3. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

.. balance the pull to individualistic work and collaboration?

1. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
2. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
3. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

.. communicate and collaborate more effectively?

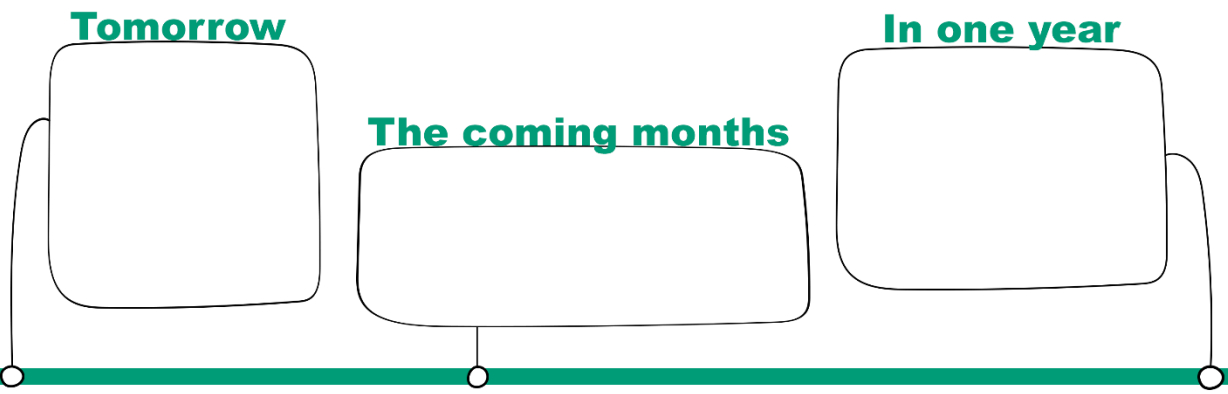
1. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
2. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
3. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

.. prioritise spending time on understanding and learning from each other?

1. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
2. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
3. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Step 2: split up into smaller groups and expand on your groups favourite solution

Step 3: clear action points for each solution



Influencing our Organisation

TU Delft

Step 1: brainstorm quick solutions to these frequent issues

How to...

.. prioritise spending time on understanding and learning from each other?

1. _____
2. _____
3. _____

.. balance the pull to individualistic work and collaboration?

1. _____
2. _____
3. _____

.. make more space and time in collaborations for working together?

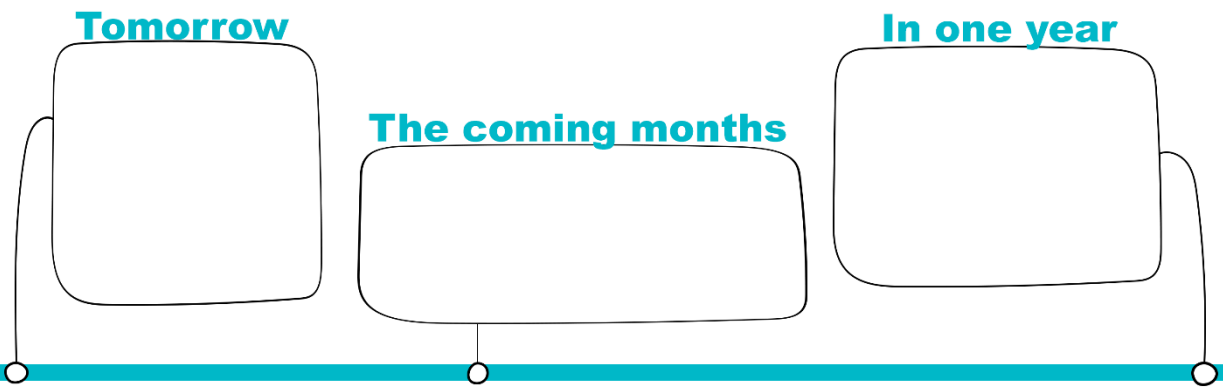
1. _____
2. _____
3. _____

.. create job and education opportunities for integrated multi disciplinarities

1. _____
2. _____
3. _____

Step 2: split up into smaller groups and expand on your groups favourite solution

Step 3: clear action points for each solution



Influencing our Academic field

TU Delft

Step 1: brainstorm quick solutions to these frequent issues

How to...

.. balance the pull to individualistic work and collaboration?

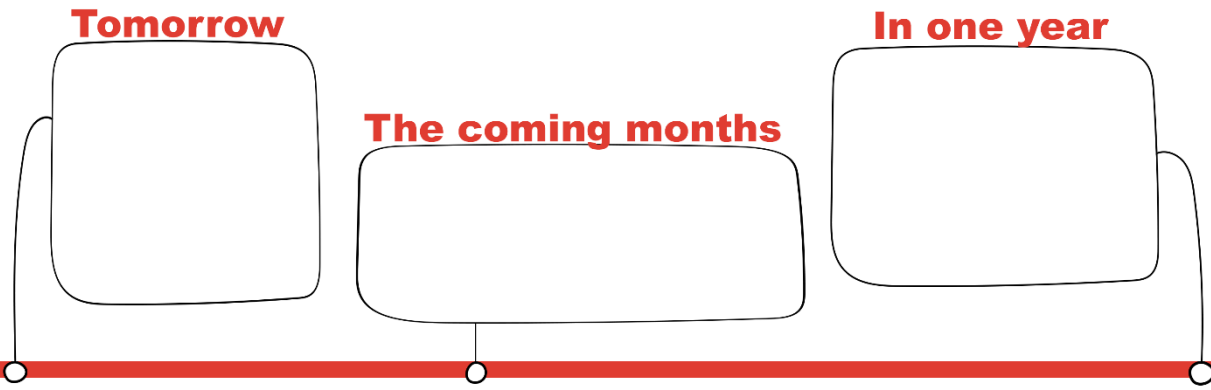
1. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
2. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
3. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

.. stimulate the field to create more integrated multidisciplinary publication opportunities?

1. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
2. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
3. _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Step 2: split up into smaller groups and expand on your groups favourite solution

Step 3: clear action points for each solution



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