Master Thesis

Juste Smitaite

M.Sc. Governance of Complex Networks (GCN) 2015-2016

Department of Public Administration, Faculty of Social Sciences

Erasmus University Rotterdam

Interdisciplinary Collaboration: Capturing a Progress of Scientific Knowledge Integration in Globaqua project

August 9th, 2016

Erasmus University Rotterdam

Faculty of Social Sciences, Department of Public Administration

M.Sc. Governance of Complex Networks (GCN) 2015-2016

Student: *Juste Smitaite (431587)*

Supervisor: *Dr. I. F. Van Meerkerk*

Word count: *46 121 (excluding References, Appendices, and Annexes)*

Summary

Drawing upon both theoretical insights and empirical findings provided by the past research, this Master thesis explores progress of scientific knowledge integration in the Globaqua project – an interdisciplinary research project, comprising leading scientists from all over Europe, and focused on integrated river basin management as a context of problem. Despite consistent attempts in the literature to apply various indicators to measuring interdisciplinarity, this study acknowledges the missing agreement in the academia on a common way for capturing scientific knowledge integration in IDR initiatives. With this in mind, this research suggests measuring interdisciplinarity progress by investigating a two-part conceptual model. For this purpose, first, the framework of van Meerkerk & Slob (2013) is invoked in capturing the evolution of scientific knowledge integration by distinguishing four composite dimensions. Second, the research employs processual interdisciplinary collaboration model by investigating the influence of four clusters of factors and conditions – professional, personal, structural, and managerial – on team learning behaviour, leading toward interdisciplinarity enhancement. Having applied an in-depth case study research design, based on triangulation of quantitative survey and qualitative interview methods, this Master thesis comes up with solid scientific findings, proving interdisciplinarity progression taking place since the beginning of the Globaqua project up to date. In addition, four main decisive factors are found to be explaining the evolutionary nature of scientific knowledge integration in the selected case. These are ever increasing degree of positive atmosphere among the project partners, as well as gradually decreasing overall degree of challenges, to which the scientists are exposed in the project. Also, a high level of self-organising capacity has been discovered on a group level as a strongly facilitating factor, coupled with the fact that the large portion of Globaqua partners share positive previous working experience. Altogether, the research findings conclusively answer the main research question, and provide both scientific and project design recommendations.

List of contents

Chapter I: Introduction

1.1. Introduction to the context

Water is the most essential of all natural resources to flora and fauna. Water and water-related services are also major components of the human well-being. In fact, naturally functioning, river basin ecosystems are the source of freshwater, and the determinants of socio-economic development globally. Yet, water resources have been increasingly used at the expense of ecosystem health (Barcelo, 2013), whilst the freshwater systems are precariously affected by human activities (Folke, 2006; Meybeck, 2003; WWAP, 2009). Consequently, most freshwater basins in Europe are currently threatened by a variety of stressors**,** such as organic and inorganic pollution, geomorphological alterations, changes in land uses, climate variability and change, and invasive species and pathogens (Vorosmarty et al., 2010; Sabater et al., 2014). They will only multiply over the coming decades, if no action is taken (Heathwaite, 2010), so, challenges in river basins remain, necessitating combating these threats, and preventing their occurrence (WWAP, 2009).

Managing river basins requires crossing administrative borders, involves divergent stakeholder interests, and transcends the scope of single scientific disciplines. Knowledge about river basins is yet unreliable and fragmented as the field is a complex and immense socio-ecological system (Barcelo, 2013; Folke, 2006). As such, protection of the world's surface water resources requires a diagnosis of threats over various scales – from global to local (Vorosmarty et al., 2010), as well as over the expertise from different scientific perspectives. With this in mind, interdisciplinary research is becoming increasingly significant in harnessing the complexity of a broad range of societal, environmental, governmental, and other problems (Thompson, 2009). These policy problems are of an unstructured type, when policy objectives and/or values are contested, and no consensus exists about the knowledge to be used in solving the issue in question (Slob & Duijn, 2014). Under such circumstances, interdisciplinary research offers a way out by forming multidisciplinary teams based on disciplinary diversity, giving them an opportunity to collaborate on joint fact-finding process in order to grapple with complex issues, and arrive at shared sets of facts to inform their joint outcomes (Schenk et al., 2016). Namely, cross-disciplinary teams aim at integrating scientific practices, as well as disciplinary conceptual models so as to move areas of research forward in ways that individual researchers could not perform as effectively on their own.

And this is what the Globaqua project aims at: integrated river basin management through interdisciplinary research among leading scientists in the field from all over Europe. A large scale 5-year EU-funded project has an explicit focus on addressing the effects of water scarcity on aquatic ecosystems by focusing on six river basins in Europe, including a wide range of academic disciplines from both sides of an intersection between the Natural and Social Sciences. Globaqua is expected to improve not only knowledge of relationships between multiple stressors, but also water management practices and policies, based on the European Union Water Framework Directive (Official Globaqua Project Website, 2016; European Council, 2000).

1.2. Scientific problem statement

Since the mid-1950s, there has been an ongoing debate on the relative merits of individual versus team–based models of research and the emergence of team science, which aims at identifying, measuring, and understanding the processes and outcomes of collaborative research of a large scale (Masse et al., 2008). There seems to be an agreement in the academic literature that IDR should be employed more to inform policy and practice on addressing critical questions and facilitating application of integrated knowledge in specific areas (Newell, 2001; Gray, 2008; Mattesich & Monsey, 1992; Bronstein, 2003; Aboelela et al., 2007). Indeed, interdisciplinarity is still a fuzzy endeavour because it is hard to define it in a unified manner. Yet, it is consistently named as the means of solving complex problems in a way that could not be addressed successfully by single disciplines. Scholars also have become increasingly aware of the need to link disparate disciplinary fields to address complex questions since the 20th century (Aboelela et al., 2007; Klein, 1990). And IDR as a collaborative knowledge production can establish these connections between researchers by enabling them to cross the disciplinary boundaries on various levels and fields (Slob & Duijn, 2014). Namely, the attempts to provide a framework for capturing the degree and the quality of IDR in practice already exist in the literature (Klein, 1990, 2008; Slob and van Meerkerk, 2013).

In contrast, there is no clear-cut agreement among scholars on how to stimulate interdisciplinarity, and steer the process of IDR, during which a synthesis of knowledge develops, and understandings change (van Meerkerk & Slob, 2013; Newell, 2001). Also, there are concerns about both the factors and the driving forces, encouraging research collaborations (Smith & Katz, 2000). Thus, even though both a structure and behaviour of interdisciplinary collaboration show evident benefits, and provide a rationale for IDR (Emerre, 2013), a decent model for capturing interdisciplinary collaboration process is missing in the academic literature.

Taking both streams into account, one faces a paradox: although IDR has a huge potential to address complex societal and scientific issues, real integration of divergent scientific disciplines during the process of collaborative endeavour rarely ever happens (van Meerkerk & Slob, 2013; Barron, 2003; Petts, Owens & Bulkeley, 2008). As such, evaluation of interdisciplinarity progress, or simply measuring research collaboration “remains one of the least-understood aspects” (Klein, 2008: 116; Smith & Katz, 2000).

1.3. Research questions and research goal

Having identified the paradox is not to deny the attempts that have been devoted up to date by various scholars in carrying out empirical investigations on a wide range of factors that hold an influence on the evolution of interdisciplinarity. A number of studies, in fact, did aim at identifying various determinants, conditioning interdisciplinary knowledge integration, however, “even well-argued conceptual categorisations have not found their way into empirical analyses of IDR” (Huutoniemi et al., 2010: 80). These efforts hence unveil considerable gaps in capturing a progress of interdisciplinarity. Granted, the academic literature not only lacks a clear framework for measuring interdisciplinarity in a given research initiative, but also does not provide markers of interdisciplinary collaboration process, during which scientific knowledge production is likely to emerge. The present study, henceforth, aims at narrowing down the just discussed

gaps in the academic literature, as well as to enhance an understanding of the determinants, decisive for the evolution of interdisciplinarity.

Therefore, **the main research question** underpinning the discussion is as follows:

How the evolution of scientific knowledge integration can be measured, and which factors hold an influence on the progress of interdisciplinary collaboration in Globaqua?

The main research idea of this study is that in order to measure a progress of interdisciplinarity, it is essential to investigate a range of factors and conditions, influencing scientific knowledge integration, in parallel. As such, interdisciplinary collaboration in the present research is perceived as a relational process of scientific collaboration among researchers, which leads to an increased performance of an interdisciplinary group, working on a specific goal. Therefore, this research goes beyond a single objective, and sets a two-fold objective. First, to assess the progress of the degree of knowledge integration in Globaqua over the life-course of the project until 2016 June. Second, to investigate factors and conditions of various types that potentially lead interdisciplinary teams toward interdisciplinary collaboration. In order to answer the main research question, five sub-questions have been formulated that will also serve as a structure of this study. These are as follows:

1) How the degree of interdisciplinarity in the project is perceived by the Globaqua participants?
2) What factors and conditions influence the process of interdisciplinary collaboration among Globaqua partners?
3) Which type of managerial strategies enhance interdisciplinarity in Globaqua?
4) How can the evolution of interdisciplinarity be explained in Globaqua?

By having answered the questions, the goal of this research is to add to the formation of a theory on which factors influence the progress of knowledge integration by carrying out a statistical analysis of the collected data, as well as by interviewing the researchers involved in the project on this influence in the field of collaboration on river basin management. Having done that, in addition to providing scientific and project organisation recommendations, this research also aims at exploring the socio-cognitive processes, underlying interdisciplinary endeavours by analysing the perceptions, concerns, and expectations of the researchers, participating in Globaqua.

1.4. Theoretical and societal relevance

Building upon the main research goal, this study bears both theoretical and societal relevance that need to be highlighted. First, the research is theoretically relevant, if it can “contribute to the specific scientific discourse and to the advancement of the knowledge, produced by it” (Lehnert et al., 2007: 25). In the case of the present study, it is to be delineated in the later chapters that the existing literature lacks core

arguments, expected to be addressed conclusively in this research. The first one relates to the measurement of scientific knowledge integration in any IDR initiatives. Currently, no commonly agreed indicators are to be applied in research, when investigating the degree of interdisciplinarity among scientists from different disciplines. Moreover, relatively scarce research attempts have been put by scholars to capture interdisciplinarity progress in terms of its processual properties. Meanwhile, the present study aims at applying the framework, developed by van Meerkerk & Slob (2013) to measuring interdisciplinarity progress in the selected Globaqua case, and drawing some generalising remarks on the reliability of the framework, as well as on certain specificities in relation to its use in future research. The second argument relates to capturing the process of interdisciplinary collaboration among scientists, during which understandings of the topic in question change and advance, and more integrated mode of doing science develops. In order to collect explanatory puzzle in a solid manner, the present study is to investigate socio-cognitive and related properties of collaborative IDR teams in order to reveal the factors and conditions of various types, facilitating interdisciplinary collaboration, and thereby enhancing scientific knowledge and practice integration. Altogether, both arguments justify the theoretical relevance of this research in significantly adding to the discourse on the evolution of interdisciplinarity in future IDR initiatives, as well as to the discourse on the collaborative research and its facilitation. Consequently, the study of such relationships is to contribute to an increased understanding of the importance of the science-science boundary crossing role in scientific knowledge production, and, to the development of practices so as to enhance further IDR initiatives.

Second, what concerns societal relevance of the research, Lehnert et al. (2007) emphasized that it should "further the understanding of social and political phenomena, which affect people and make a difference with regards with explicitly specified evaluative standards" (p. 27). As such, the present study essentially adds to advancing one's understanding of what interdisciplinary collaboration is in the context of a large scale IDR, as well as to enhancing the collaboration discourse on factors, influencing IDR process. As such, the analysis of the Globaqua case will unveil the complexity of river basin management, and, more importantly, of the process of interdisciplinary collaboration, in which active involvement of a range of stakeholders with various epertise and scientists from different disciplines is present. Hence, the findings of this research will provide a more profound picture of how this complex processual puzzle unfolds in practice, how to manage it, and what challenges to expect that would not only make the society more aware of the benefits and rationale of research collaboration, but also would allow the academia obtaining rich insights on how to proceed with IDR in order to ensure unleashing its potential in addressing complex societal and socio-economic issues.

1.5. Research structure

Having introduced the topic and the main focus of the present study, the following – Chapter 2 will start of by introducing the theoretical framework of this study, based on two complementary approaches that enrich the discussion on interdisciplinary collaboration. Interdisciplinarity discourse is to provide an approach to interdisciplinarity as scientific knowledge synthesis as a basis for contemporary interdisciplinary studies. Meanwhile, collaboration approach will add to the interdisciplinarity discourse with an important group relational aspect, interpreting it as an interpersonal learning process towards collaborative knowledge

production. Granted, a conceptual model will embrace both perspectives into a process model for interdisciplinary collaboration in this research. Chapter 3 will then introduce the research design of this study. Some loose theoretical expectations of the relationship between certain variables will be defined, as well as methodology of this research will be discussed. To add, the overall standpoint towards the model in the context of the present study will be elaborated. Chapter 4 will then introduce the case of this study – the Globaqua project, and will present its management and organisational setting. Further, Chapter 5 will introduce the first part of the empirical part, by investigating the dependent variable of this study – the degree interdisciplinarity in Globaqua. The subsequent Chapter 6 will then extensively discuss the factors and conditions, influencing interdisciplinary collaboration in Globaqua. Then, Chapter 7 will provide a reader with an overall reflection on the conceptual model of this research, by looking at both quantitative and qualitative results, and will address the core question of how to measure an evolution of scientific knowledge integration. Lastly, Chapter 8 is to finalize this study by answering the main research question, when highlighting the main findings of the research, and providing profound insights and recommendations to both Science and Project coordinators in the context of interdisciplinary collaboration.

Chapter II: Theoretical framework

It is no secret that interdisciplinarity theory is in *statu nascendi*. For this reason, a theoretical framework of this study is to be shaped by merging two complementary perspectives. First, interdisciplinarity discourse will be broadly presented as the core approach in this research. Its early development in the context of interdisciplinary studies will be elaborated, coupled with a discussion on a cross-disciplinary research and a four-dimensional progress framework of scientific knowledge integration. Second, collaboration perspective is to be employed to enhance interdisciplinarity theory with a relational component of interdisciplinary research (IDR) endeavours. It will offer an extensive discussion on drivers of and barriers to interdisciplinary collaboration of various types. A systematic support of both theoretical and empirical literature on IDR and collaboration will accompany both approaches. As a result, a two-part conceptual model to be further employed in the analysis of this research will be set at the end of this chapter.

2.1. Interdisciplinarity approach

2.1.1. Interdisciplinary studies

The need for meaningful interaction is almost everywhere. The discourse on interdisciplinarity is hence widely dispersed – the discussion on *interdisciplinarity* is scattered across various fields – academic, professional, governmental, to name a few, and significantly differs in the scope of the discussion. Further, it is usually accompanied by a variety of (possibly) divergent values, perceptions, ideas and questions of people, involved in problem-oriented IDR, that often make the outcome of interdisciplinarity vague. Therefore, an explicit focus is put on scientific knowledge integration in this study, it is elaborated further.

There is an agreement in the academic literature: the roots of interdisciplinarity date to the twentieth century, when it was recognized as an emergent field of research. That happened as a consequence of calls for more holistic perspectives on issues that put tensions upon the classical division of disciplines (Klein, 1990). This overlapping amongst disciplines induced the development of interdisciplinary studies, and shaped the formation of 'the theory' of interdisciplinarity, which is yet in its maturation process.

Accordingly, since mid-1950s, natural, behavioural and social sciences have undergone the shift from individually-oriented research toward team-based scientific collaboration, which marked a growing emphasis on a cross-disciplinary approach to research (Masse et al., 2008; The National Academies, 2005). A second half of the twentieth century has also been identified as the time, when the restructuring of knowledge took place due to the emergence of comparative studies, collaborative research, team teaching, and other forms of 'joint studies' (Klein, 1990). Yet, the process of an extensive disciplinary borrowing seemed to be leading towards a "profound epistemological crisis" (Ibid: 11) because numerous scientific problems could easily be defined as 'interdisciplinary': in the pioneer seminar on interdisciplinarity, held by OECD in 1972, the notion was described as the "discipline of tomorrow" (Ibid: 78). The universal nature of interdisciplinarity, thus, enabled addressing a wide range of goals, beyond the scope of single disciplines.

At the same time, this universal nature of interdisciplinarity caused a great deal of confusion among teachers and scholars, aiming to engage in IDR due to both uncertainty over the definition, as well as unfamiliarity with interdisciplinary scholarship (Ibid). Consequently, most of interdisciplinary courses that were being developed and applied in colleges and research institutes at a time "involved no real merging of subject matter except in the catalogue" (McGrath, 1978: 7). Generally, the concept of a wide appeal has suffered from vagueness over the course and the outcome of IDR then, as well as it does today. That is hardly surprising as it is impossible to define theoretical models that span conceptual space of different disciplines in a unified manner, or even to transform existing beliefs simply by showing evidence from other fields (Huutoniemi et al., 2010). As such, the concept is often accompanied by an uncertainty shield.

The prevailing ambiguity in the discourse of interdisciplinary studies is indeed related to a complex nature of interdisciplinary studies. Pairing of interdisciplinarity and complexity hence is no coincidence. Conversely, theoretical justification of interdisciplinarity is grounded in the nature of complex systems: IDR is necessary only, if either a behaviour, produced by the system, or the system itself is complex (Newell, 2001). As such, complexity derives from the fact that disciplines are divided by scientific boundaries, which impedes the possibility to produce theoretically-informed solutions to problems through an integration of knowledge across the boundaries. Since the division of disciplines is irrevocable, it is crucial to understand, what constitutes disciplinary knowledge prior continuing on the discussion of interdisciplinarity.

Disciplines are the constructs of an interplay of historical processes that formed around specific objects, and are highly dynamic (Abbott, 2001; Petts, Owens & Bulkeley, 2008). Generally, academic boundaries are established by the differences in methods, theories and conceptual frameworks, rather than by a subject matter (Klein, 1996). That is to say that science-science boundaries "are hard to cross as they use different concepts and vocabulary" (Slob & Duijn, 2014: 354). So, although different disciplines may address the same issue (which is often the case), their theoretical, methodological and conceptual approaches are simply not of the same nature. Bruce et al. (2004) explained the reason behind such robustness of disciplines: disciplinary boundaries maintain their structuring power because "they serve a very useful function of constraining what the academic has to think about" (p. 467). Shared language and concepts, thus, are what bind similar disciplines, as well as what distinguishes them from their counterparts. The cognitive boundaries, yet, are challenged by the emergence of complex challenges that span beyond the capacity of single disciplines, so, the rationale for crossing the science-science line is primarily enabling collaborative knowledge production (Slob & Duijn, 2014; van Meerkerk & Slob, 2013; Newell, 2001), rather than denying transdisciplinary nature of issues, and further addressing them from limited single-disciplinary perspectives.

Granted, traditional disciplinary boundaries are considered to serve as a precondition for interdisciplinary collaboration. Yet, the severity of epistemological barriers between disciplines surfaces because more than one discipline is applied in the search for an integrated solution, and that is where interdisciplinary collaboration is to emerge, often inducing a confusion within both the academia and researchers community in terms of semantics (Petts, Owens & Bulkeley, 2008). In order to pre-empt this confusion, theoretical discussion on the different types of a cross-disciplinary research, as well as on a four-dimensional interdisciplinarity progress is provided in the following section.

2.1.2. Interdisciplinary research

Types of a cross-disciplinary research

One of the first serious attempts to conceptually categorize IDR is the widely recognized division of multidisciplinary, interdisciplinary and transdisciplinary types of research in order to measure, analyse and identify the degree of interdisciplinarity in actual research efforts (Huutoniemi et al., 2010). All three types span a wide range of contexts (Klein, 2008), while sharing conceptually similar, loosely operationalised characteristics. Although three cross-disciplinary research types are widely discussed in the literature, a unidisciplinary type of research is useful to be introduced as a starting point for further categorisation. As such, *unidisciplinary* research is grounded in the application of a theoretical approach to a given problem, drawn from a single field (Hall et al., 2008). The usual procedure is to organise disciplines into three main clusters – social sciences, natural sciences, and humanities (Klein, 1990), and, in this respect, a given discipline provides crucial elements: knowledge, methodology, and tools for prospective multidisciplinary, interdisciplinary, or transdisciplinary work.

With regard to a cross-disciplinary research, *multidisciplinary* is the first level, in which two and more disciplines are involved in the argument of an issue at stake. Multidisciplinary research is a conglomeration disciplines, in which they co-exist, and instead of adaptation or synthesis of knowledge, robust disciplinary boundaries and academic identities are retained (van Meerkerk & Slob, 2013; Petts, Owens & Bulkeley, 2008). Multidisciplinary collaboration, thus, is an activity, inviting researchers to share their disciplinary insights and perspectives with their counterparts (Hall et al., 2008), with no attempt to reach a shared cognition. Efforts to highlight the autonomy of single disciplines in grasping particular questions is intrinsic instead, and, therefore, multidisciplinarity should not be seen as failed interdisciplinarity (Petts, Owens & Bulkeley, 2008).

The second level of a cross-disciplinary research is *interdisciplinary* mode of research, undertaken either by individuals, or teams, when address problems, created by differences in disciplinary cultures (van Meerkerk & Slob, 2013). In other words, IDR transcends the inherent nature of multidisciplinary research in order to put the solved problems on the shelf for later use (Thompson, 2009). Moreover, IDR encompasses not only the relationship between disparate research paradigms, for instance, between social and natural sciences, but also between the disciplines within these paradigms (Marzano et al., 2006). As such, interdisciplinarity aims at integrating theoretical perspective, concepts, knowledge, data, techniques, and tools from more than one body of knowledge or discipline so as to enable novel solutions to the problems that are beyond the scope of a single discipline, or of a research practice (The National Academies, 2005). In this respect, IDR is not just a simple mix of disciplines *per se* (Abbott, 2001), but rather embodies certain level of integration, and refers to the emergent *synthesis* of knowledge across disciplinary boundaries (Klein, 1990; Klein, 2008; van Meerkerk & Slob, 2013; Hall et al., 2008; Aboelela et al., 2007; Newell, 2001). To clarify, synthesis refers to the core idea behind IDR to integrate the best practices, as well as analytical strengths from multiple disciplines into a coherent mode of research for understanding complex issues (Newell, 2013). That is what principally distinguishes multidisciplinary and interdisciplinary types of research. By engaging in seemingly unrelated disciplines, according to Aboelela et al. (2007), “traditional gaps in terminology, approach, and

methodology might be gradually eliminated", and "a true meeting of minds can take place" (p. 331). For this reason, the notion of interdisciplinarity in this study is used as a synonym of scientific knowledge and practices integration in the context of IDR initiatives.

The third – *transdisciplinary* type of research mostly relies on the characteristics of IDR, so, the distinction between the two is not easy to tease. Transdisciplinary collaboration also strives toward integration of disciplinary perspectives, and "the creation of novel conceptualizations and methodologic approaches that transcend, or move beyond the individual disciplines represented among team members" (Hall et al., 2008: 164). Yet, two attributes facilitate a conceptual difference between IDR and transdisciplinary research. First, transdisciplinarity refers to an invention new Science by the researchers, exploring the same research questions at the intersection of their respective fields for knowledge re-integration (Gray, 2008). That is to say that transdisciplinary activity may give birth to new hybrid disciplines, contribute to the development of a new field of study, as well as of a scientific language (Aboelela et al., 2007). Second, transdisciplinarity also includes information and knowledge of stakeholders involved (van Meerkerk & Slob, 2013).

A summary of the three types of a cross-disciplinary research is provided in Table 1 below.

Table 1. Three types of a cross-disciplinary research

Type of research	Multidisciplinary	Interdisciplinary	Transdisciplinary
Characteristics	Different disciplines approach an issue in question in parallel, without aiming to achieve scientific knowledge and practice integration. Rather, through a cooperation between different disciplines, autonomy in solving issues from single disciplines prevails.	Application of various academic perspectives, when addressing complex issues. Through an interaction between different disciplines, integration of scientific knowledge and practices is to develop. Synthesis of knowledge as a result of interdisciplinary collaboration emerges, and understandings advance.	Similarly to IDR, transdisciplinarity aims at integration of disciplinary perspectives. Yet, by including information and knowledge from a range of stakeholders involved, new science is likely to emerge as a result of transdisciplinary activities.

Source: Developed by the author

Dimensions of scientific knowledge integration

The above presented categorization of a cross-disciplinary research is valuable for developing an evaluation tool for IDR (Huutoniemi et al., 2010). As the science-of-team-science is still at a relatively early stage of its maturation, it surely could benefit from the valid and reliable measures of collaborative IDR processes in terms of scientific knowledge integration (Masse et al., 2008). As a result, the question of how to capture a progress of knowledge integration in IDR initiatives remains open.

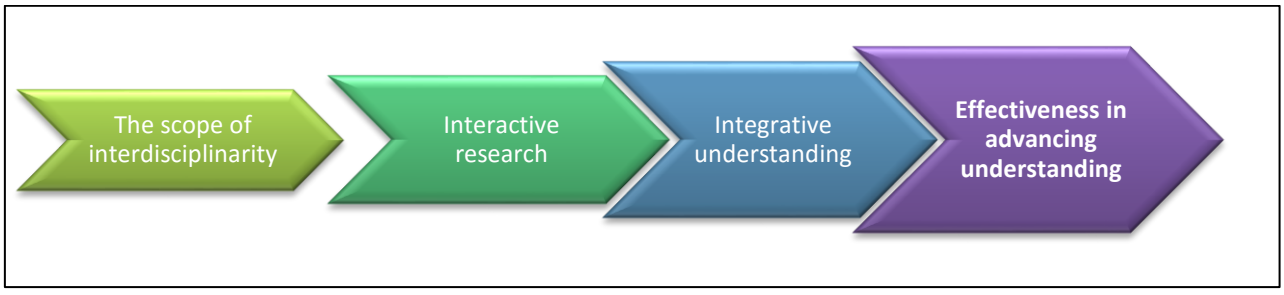
In order to depict the complexity of interdisciplinarity, the degree of interdisciplinarity may range, for instance, from mere personal interdisciplinary orientation in the context of multidisciplinary research to the advanced understandings, based on various disciplines. Also, from simple sharing of single ideas to the

mutual construction of organising concepts, methodology, procedures, and developed interdisciplinary learning. Further, not only the criteria for evaluating interdisciplinarity progress vary across dimensions, but also projects and other types of IDR initiatives differ in their focus domain, institutional settings, objectives, and other aspects. Altogether, a wide range of possibilities to measure interdisciplinarity fit into the so-called "interdisciplinary continuum" (Adler & Flihan, 1997) or "a continuum of collaboration" (Aboelela et al., 2007), encompassing a gradual interdisciplinarity progress, spanning from correlated to re-constructed knowledge.

Having acknowledged the complexity of both the evaluation of interdisciplinarity, Huutoniemi et al. (2010) came up with a spectrum of categorisations of IDR in terms of three groups of focus: degree of knowledge integration, interdisciplinary practices, and rationales of interdisciplinarity, and introduced qualitative indicators defining IDR, based on an extensive literature review. As a result, the authors proposed a hybrid analytical framework as a remedy to the deficiencies in earlier efforts to both define and operationalise IDR (see p. 81-85). In addition, Klein (2008) presented an expanded list of seven generic principles for evaluation IDR, for example, in terms of variability of goals, variability of criteria and indicators, interaction of social and cognitive factors, management and coaching, and other (see p. 118-122). Nevertheless, although these and other scholarly attempts imply an agreement in the academic community on the basic vocabulary of interdisciplinarity at the conceptual level, no common indicator has been accepted for science purposes to measure a progress of interdisciplinarity in practice (Huutoniemi et al., 2010).

In the context of this study, the attempt to conceptualise a progress of interdisciplinarity is grounded in the core idea behind IDR: according to Krott (2003), integration is deemed as the critical point for evaluating interdisciplinary initiatives. Therefore, having systematically explored the existing literature on interdisciplinarity, as well as counting on a framework, developed by van Meerkerk and Slob (2013), a four-dimensional progress model is introduced in Figure 1, and further discussed.

Figure 1. Four-dimensional progress framework of interdisciplinarity



Source: Developed by the author, based on the framework of van Meerkerk & Slob (2013)

The first dimension – *scope of interdisciplinarity* – refers to a composition of the group, participating in IDR initiative in terms of disciplinary diversity. A general indicator is a number of different disciplines, represented by the partners involved, as well as what different types of disciplines participate (van Meerkerk & Slob, 2013). As such, the scope of interdisciplinarity may be either broad or narrow in its scope, and reflects "conceptual and cultural distance between the participating research fields" (Huutoniemi et al., 2010: 82).

The second dimension – *interactive research* – closely relates to the actual interaction that is present among disparate disciplines in the context of IDR initiative. Another composite item of this dimension can be expressed in terms of the scale of contacts between team members, and the degree to which they share the information (Aboelela et al., 2007), as well as in terms of time, devoted for interaction between truly different academic disciplines. Both features embody a reflection of how densely, and how often partners of IDR actually collaborate with each other, when working on the same issue in question. Further, additional features of this dimension indicate a certain level of integration between the participating disciplines in terms of research methods, theories, and models each of them apply, when addressing scientific questions. As such, these characteristic items conform to what Adler and Flihan (1997) defined the first stage of interdisciplinary continuum – "correlated knowledge" (p. 5). The authors defined it as an interaction among the researchers from juxtaposed disciplines that maintain traditional boundary division, but, at the same time, attempt to emphasize broad-based connections between subjects in order to justify the correlation between involved disciplines. So, the question "what research components are being integrated" arises (van Meerkerk & Slob, 2013: 11). Altogether, these features form a second dimension, marking interdisciplinarity progress.

Third, integrative understanding ideally represents the third out of four dimensions. The main aspect, distinguishing this and the previous stage of interdisciplinarity progress, is that researchers still remain loyal to their respective disciplinary language, but also truly engage in comprehending the language of other disciplines, and hence enable sharing of understanding among disparate disciplines (Aboelela et al., 2007). In this respect, knowledge becomes something to be actively shared between often disparate disciplines, characterizing the third dimension by "overlapping concepts and emergent patterns" (Adler & Flihan, 1997: 6). From a cross-disciplinary approach, integrative understanding emerges "as a result of sifting related ideas out of subject matter content" (Ibid: 7). As such, integrative understanding emerges, concerning the empirical phenomenon (van Meerkerk & Slob, 2013).

The final dimension in the literature is perceived as advancing fundamental interdisciplinary understanding among disciplines (The National Academies, 2005) in the shape of a synthesis of all theoretical approaches involved through cross-disciplinary learning. IDR that advances on this dimension not only borrows methods across disciplines, but also reconstructs knowledge by fully eliminating disciplinary boundaries (Adler & Flihan, 1997), and developing novel insights, which would have otherwise not happened by following a mono-disciplinary way of addressing an empirical phenomenon (Boix-Mansilla, 2006).

To sum up, a four-dimensional sequence of increasingly higher degree of interdisciplinarity is expected to lead toward improved research outcomes in terms of advanced understandings. As a result, the model is to facilitate greater recognition of interdisciplinarity progress within an IDR project.

2.2. Collaboration approach

2.2.1. Collaboration as a relational endeavour of an increased performance

Since the core concept in this study is interdisciplinary collaboration, it calls for a sufficient complementary body of knowledge to be introduced in order to enrich interdisciplinary discourse with a relational aspect of IDR. For that reason, the perspective of collaboration is chosen to be discussed further.

Generally, 'collaboration' is a large body of knowledge that denotes the process of collaboration as a mode of partly coordinated relationship that shapes social interaction among people, or among groups of people in a particular way. More importantly, Bruner (1991) emphasized collaboration among people as a means to an end, rather than an end goal on itself. That is to say that collaborative efforts bind people to engage in joint activities of either a short or long period of time, and, at the same time, facilitate interaction between them through the creation of an ownership of an issue in question. As such, collaboration is "the existence of a relationship" between units that intend to work together, either of a formal or an informal organisation, and may be structured for, but not limited to a project or other type of activity (Berg-Wener & Schneider, 1998: 99). In addition, collaboration is also a process-based activity for not only building, but also maintaining and developing a shared conception of a problem, as well as for distributing responsibility across collaborating people, enabling sharing of expertise, and eventually contributing to construction of mutual cognition (Rochelle, 1992 in Van den Bossche et al., 2006).

Sufficient exploration of the literature on collaboration suggests two main themes that can be distinguished in order to provide a substantial theoretical base for defining IDR as a collaborative endeavour. The first theme relates to a well-elaborated relational dimension, when the discussion of social interaction is in question. In this respect, collaboration is perceived as interpersonal process of working together around a given task, and, with no doubt, this process is of a highly dynamic nature (Mattesich & Monsey, 1992). That is why the most widely discussed characteristics of collaboration are related to the concept of 'relational endeavour' (Hord, 1986), which can take place either on a corporate, team, or inter-personal levels (for more detailed description of these types, see Smith & Katz, 2000, p. 13-16). Further, collaboration mostly takes place in any of three areas – clinical and/or community service, education, and research (Berg-Weger & Schneider, 1998). The latter is central to the present study, and refers to an engagement in scholarly endeavours with academicians from other disciplines (Ibid).

It should be noted that while there is little argument about the value of collaboration among various types of actors, the way the act of collaboration is defined varies per authors, as well as per fields, in which collaboration is practiced. It is, in fact, often incorrectly identified as a synonym of 'cooperation'. In contrast, different attributes are inherent to cooperation and collaboration that make them two totally distinct operational processes that require different kinds of inputs, and yield diverse returns (Hord, 1986).

What concerns the second prominent feature of collaboration, empirical evidence shows that it should be defined as a means to increase both personal and team gains in terms of performance and learning. This provides the core rationale for collaboration: people engage in collaborative process because they seek to

achieve the goals, which otherwise would not be achieved, if acting individually, or at least not as efficiently (Van den Bossche et al., 2006; Bruner, 1991; Hall et al., 2008; Hord, 1986). Consequently, teams are perceived to be more effective in addressing same issues, so, most of the time they achieve an increased perceived performance. By committing to collaborative endeavour, people become presumably able to solve a wide range of issues that derive from an individual work (Bruner, 1991). Hence, collaboration is mutually beneficial relationship between partners of temporary groups (Mattesich & Monsey, 1992).

Undeniably, collaborative approach enriches interdisciplinarity discourse by providing a substantial insight on the relations between multiple actors, involved in the social interaction for a given purpose, and hence justifies the rationale for stepping out of a state of self-separation in the context of a team-work in order to connect with one's counterparts for an improved performance. In addition, effectiveness in performance eventually leads collaborative teams toward reciprocal learning, which is central to interdisciplinarity.

2.2.2. Collaborative behaviour of interdisciplinary teams

Temporary collaborative IDR teams

Interdisciplinary teams undeniably provide a new field for the study of collaboration. When speaking about learning capacity of collaborative teams, 'the team' plays a key role in the discussion (Emerre, 2013). Together with a growing recognition of the urge to solve transdisciplinary problems, and address complex scientific questions, the funding grew, and so did the opportunities for IDR (Klein, 1990). Consequently, temporary interdisciplinary groups have emerged hand in hand with the expansion of interdisciplinary studies as a common form of organisation (Thompson, 2009; Meyerson, Weick & Kramer, 1996). Generally, temporary collaborative teams are formed around a common task, with relatively clear goals, a finite life span, and are highly dependent in terms of their success on a coordinated coupling of activities (Meyerson, Weick & Kramer, 1996). Such groups, consisting of members with diverse professional and academic background and skills share only a limited history of working together (if any), and work under tight deadlines that leave little time for relationship and trust building (Thompson, 2009). In addition, collaborative practices of IDR teams differ greatly from discipline to discipline (Emerre, 2013). Generally, an underlying incentive, often cited as the main advantage of such teams, is the opportunity to maximize the creativity with today's wicked problems through merging the expertise and knowledge from different disciplines (Bronstein, 2003).

Looking from the systems theory point of view, temporary IDR teams, however, are complex adaptive systems, characterized by non-linear, unpredictable and hardly manageable interactions among their members that shape the evolution of the whole collaborative team (Thompson, 2009; Newell, 2001). Theory also justifies the above discussed insight into the rationale of collaboration among people, indicating that through a close interpersonal interaction people get the opportunity to create what otherwise would not be feasible, if acting independently (Bronstein, 2003). To top it off, theory suggests looking at this dynamics within and among collaborative teams in order to trace the potential patterns of communication, which might provide a valuable overall puzzle for investigating future collaborations.

Hence, with regard to collaboration as a mode of to some extent coordinated relationship, Bronstein (2010) invoked the two-type classification of team-work by Kane (1980)[1], and introduced coordinated and integrative forms of teams. Only the latter is relevant to this study as it more closely resembles collaboration among a group of people, being interrelated and interdependent in carrying out a joint goal, rather than based on distinct professional roles, non-consensual decision-making, and little emphasis on group process that is inherent to coordinated teams (see p. 300). In the context of no top-down coordination, communication within collaborative initiatives unfolds in unpredictable ways. This is central for capturing collaborative learning capacity of teams as it enables relational contact. In other words, open and frequent human communication serves as a connecting driver, as well as it enhances knowledge exchange by bringing distinct forms of it into fruitful integration (Mattesich & Monsey, 1992; Marzano, Cars & Bell, 2006). Not a few studies confirm the importance of direct communication in temporary collaborative teams. As such, Soler and Shaufer (1993) contributed with their empirical finding to the argument of communication, proving that successful collaborative efforts partly rely not only on frequent, but also effective communication that spans professional and/or disciplinary boundaries. Also, Thompson (2009) summarised multiple studies on effective group communication with a conclusion of communication processes being fundamental to team's success. Communication act is, therefore, often defined as a 'discursive collaboration', during which conversational patterns emerge, reflecting socio-cognitive processes among people, engaged in collaboration (Van den Bossche et al., 2006).

Collaborative team learning

Collaboration as a large body of knowledge, also includes the research on collaborative learning, which mainly focuses on the above mentioned socio-cognitive processes, leading toward the formation of shared conception framework, and bears potential to reveal conditions for improved team performance (Van den Bossche et al., 2006). In fact, Dillenbourg et al. (1996) stated that learning through collaboration is a phenomenon that takes place only on a group level. Hence, it occurs through sharing of conceptual differences and developing joint interpretation for the purpose of knowledge convergence.

It goes without saying, however, that collaborative team learning does not happen per se. It rather develops and consolidates through three main stages of temporary collaborative endeavours, which in this study are distinguished based on the literature. The first stage accounts to *collaborative efforts* that emerges, having established a collaborative team. Initial discursive practices start shaping an early-stage social context – atmosphere, and socio-cognitive processes simultaneously develop at the moments IDR partners interact with each together (Van den Bossche et al., 2006). Having in mind that a number of different, or even disparate disciplines are put together to achieve a common goal, multidisciplinary composition of a collaborative environment exists, in which partners act for the task performance. Tasks are assigned to all

[1] Kane, R. A. (1980). Multidisciplinary Teamwork in the United States: Trends, Issues and Implications for the Social Worker. In S. Lonsdale, A. Webb, & T. L. Briggs (Eds.), *Teamwork in the Personal and Social Services and Health Care* (pp. 138–151). London: Personal Social Services Council. The original source has not been included in the reference list of this paper as it is not accessible on the Internet, or through any other sources available to the author of this study.

interdependent members of the project, and may be achieved only through collaboration due to interdependent disciplinary knowledge and resources of the participants. As a result, IDR partners inevitably start working on joint modules and have individual responsibilities. The process of sharing ideas and perspectives on a given issue begins, which has been defined by Van den Bossche and colleagues (2006) as "construction of knowledge" (p. 495). Looking from the perspective of collaboration, knowledge or meaning construction is the very first step of the collaborative team learning process: it entails the articulation of a personal meaning (Stahl, 2000), which is being inserted, while discussing the issue and its potential solutions from the standpoint, inherent to particular disciplines (Van den Bossche et al., 2006). Partners engage in interactive discussions, during which disciplines are brought to the table and applied separately for exploring particular topics, and the process of meaning construction starts. Past research shows, however, that "in the early stages of team development, members are cast into a wide range of interpersonal roles, and, thus, the variances on prominence, sociability, and task orientation are high" (Farrell, Schmitt & Heinemann, 2009: 294). Due do this, partners are exposed to various challenges.

Altogether, collaborative efforts stage provides a primary picture of group performance, and so enables an initial study of the socio-cognitive processes within temporary IDR groups. Several factors that are fundamentally social, according to the literature, naturally develop at this stage of collaborative learning process. In particular, specific atmosphere or social context emerges, also, certain challenges with regard to collaboration emerge. A careful look at these factors at this stage of collaborative learning may inform the studies on collaborative team behaviour in the context of IDR (Van den Bossche et al., 2006).

Second, theoretically, collaborative efforts stage is presumed to evolve in a linear manner, and develop into a *collaborative capacity* stage, which that involves multiple interactive dynamic processes within teams (Hall et al., 2008)**.** Whilst in collaborative efforts stage people from different scholarly backgrounds assign qualitatively different meanings to the same issue, in the stage of collaborative capacity, the underlying requirement for the IDR team is to transcend these differences, and take a step further toward mutually shared cognition. In order to reach this stage, conversational patterns need to be intensified in IDR teams. More specifically, it could only be achieved through "recognition, reflection, and negotiation of meaning, especially in interdisciplinary contexts" (Thompson, 2009: 286). This team knowledge construction also is referred in the literature to "co-construction", "collaborative knowledge construction" (Van den Bossche et al., 2006), or "collaborative knowledge production" (van Meerkerk & Slob, 2013). It should be noted that this process is grounded in horizontal integration that "alters the architectonics of knowledge by strengthening connections outside what is regarded as the discipline proper" (Klein, 1990). As such, co-construction is the successive stage of collaborative team learning, during which a team is capable to develop certain level of institutional, personal, and professional trust, such as interpersonal trust, and constructive conflict practices (Van den Bossche et al., 2006). As a result, "we" feeling develops within the team, creating a problem 'ownership' (Hord, 1986).

Third, the process of co-construction leads to advanced understandings, as a result of collaborative capacity developed. So, shared cognition eventually leads to increased performance of collaborative groups in interpersonal environment (Van den Bossche et al., 2006), and reaches the final *interdisciplinary*

collaboration stage. Although in most of the IDR projects it is perceived as an end goal in terms of tangible outcomes, in this study, in contrast the approach to interdisciplinary collaboration as a desired stage of a relational process among IDR partners is more appropriate. New meanings that emerge go beyond multidisciplinary understanding, meaning that the knowledge of collaborative team members has been advanced, and so an interdisciplinary framework around the issue at stake sees the light (van Meerkerk & Slob, 2013). As a result, not only mutual learning and shared cognition, but also intellectual integration of "knowledge emerges as novel insights are generated, disciplinary relationships redefined, and integrative frameworks built" (Klein, 2008: 119).

Overall, many important phases in the collaborative knowledge-building can be delineated, according to Stahl (2000). Yet, having discussed all three stages, collaborative team learning behaviour can be defined as social "processes of construction and co-construction of meaning, with constructive conflict as vehicle to enhance co-construction", and it conditions mutually shared cognition, leading to interpersonal trust, and higher team effectiveness (Van den Bossche et al., 2006: 502; Mattesich & Monsey, 1992).

2.3. Interdisciplinary collaboration

2.3.1. Defining interdisciplinary research

As discussed, the concept of IDR is of a broad appeal, so, lack of understanding of how to properly define it prevails. Also, although it is evident that IDR has enormous potential to Science, both varying interpretations of the concept across disciplines, as well as different expectations of participants regarding the process of IDR exist. Hence, a unified definition of interdisciplinary collaboration would ideally inform on the conditions and processes, related to the desired interdisciplinary collaborative contribution to science-science intersection (Aboelela et al., 2007). And even though many scholars have contributed to defining interdisciplinary work, an overarching definition does not exist as it is hard to define IDR in a unified manner (Marzano, Carss & Bell, 2006; Klein, 1990; Huutoniemi et al. 2010; Slob & van Meerkerk, 2013). A number of definitions of interdisciplinary collaboration, present in the literature, hence point more or less in the same direction. The main difference dividing them in two conceptual camps, however, is related to the interpretation of IDR either as a tangible end result, or as a process.

On the one hand, IDR is often considered as 'an intended outcome', to be achieved while engaged in interdisciplinary work. Authors mainly analyse and assess the (successful) performance of IDR, based on its final result – a tangible product, for instance, an integrated solution to a particular problem, a map, a publication, a method, a synthesis of various disciplines, and other (Huutoniemi et al., 2010; Klein, 2008; Aboelela et al. 2008; Slob & van Meerkerk, 2013). In this respect, the process of IDR seems to be neglected in the evaluation, albeit the outcome of interdisciplinary initiative becomes the core indicator for measuring the degree of scientific knowledge integration. It is important to note that Porter et al. (2008) have carried out an important study by developing and testing promising quantitative measures of integration research outputs, as well as of the specialisation of produced research outputs to evaluate the impact of the IDR initiative. In this context, the most often applied indicator – a number of publications of IDR teams (Bergmann

et al., 2005; Porter et al., 2008; Klein, 2008), is also being increasingly questioned in terms of its accuracy and legitimacy in the literature. Nonetheless, "interdisciplinarity has become a widespread mantra for research, accompanied by a growing body of publications" (Klein, 2008: 116).

On the other hand, IDR can be defined as 'a process of scientific knowledge integration' (Huutoniemi et al., 2010; Marzano, Carss & Bell, 2006, van Meerkerk & Slob, 2013; Klein, 1990; Porter et al., 2008). In this respect, unlike in the above discussed approach toward IDR, the process of interdisciplinary endeavour itself is an intended outcome. Of course, adding researchers from various disciplines to work together does not make the initiative interdisciplinary – people have to make a conscious, continued effort to coordinate their language and behaviour with respect to shared knowledge (Aboelela et al., 2007; Rochelle & Teasley, 1995, in Van den Bossche et al., 2006; Marzano et al., 2006). Further, the quality of the integration process in particular is of a high importance as well (Klein, 2008). That is why instead of a hierarchical and modernistic approach, IDR teams "instigate a more deliberative, collaborative, and practice-based way of producing knowledge"; horizontal bottom-up knowledge production hence displaces expert-fed, top-down practices (Slob & Duijn, 2014: 351). So, the process is the most debated aspect of IDR because when two or more disciplines come together, horizontal knowledge integration is theoretically under way (Huutoniemi et al., 2010; Klein, 1990). Furthermore, having in mind its dynamic nature, the process of scientific knowledge integration cannot take place based on a predetermined plan.

Having combined both insights from interdisciplinarity discourse, as well as from the approach of collaboration, academic attempts to define interdisciplinary collaboration seemingly share similar elements. To mention a few, Andrews (1990) labelled the process as occurring when professionals, possessing knowledge, skills, organisational perspectives, and personal attributes, specific to their individual experience, commit to achieve a common objective through a coordinated problem solving. Further, Berg-Weger and Schneider (1998) have built their definition of interdisciplinary collaboration on the one of Andrew's, and markedly emphasized an interpersonal element of the process in the reach for shared goals. Finally, Welch (2011) introduced a more ambitious definition, describing the process as an innovative opportunity to comprehending, navigating, and transforming knowledge (Welch, 2011). Therefore, these three definitions serve as a basis for the approach to interdisciplinary collaboration in this study. Notably, interdisciplinary collaboration notion is used as a synonym to IDR in this study.

To sum up, interdisciplinary collaboration is an interpersonal process, during which various and often disparate disciplines are blended, and materialise in a synthesis of knowledge. Shared cognition, as a consequence, develops simultaneously. Second, interdisciplinary collaborative initiatives should be driven by a conscious effort made by the participants to build close relations with co-researchers through discursive collaboration (Marzano, Cars &Bell, 2006). Lastly, interdisciplinary collaboration process is grounded in the assumption that IDR teams naturally operate only through the learning across disciplines. With this in mind, process steering rather than a top-down management of IDR initiatives is valuable to provide some guidance. It is essential to add that collaborations among disciplines and researchers "is increasingly being seen as the best way of addressing problem-oriented research" (Emerre, 2013).

2.3.2. Factors and conditions, influencing interdisciplinary collaboration

As the science of team science is rapidly evolving, not only the identification, but also the assessment and the development of contributing factors, conditions, and relational processes within and among IDR teams are critical for actualising effective collaboration (Masse et al., 2008; Bronstein, 2003; Emerre, 2013). Many authors, in fact, have identified multiple factors that are essential to (successful) interdisciplinary team-work – Aboelela et al., 2007; Klein, 2008; Marzano, Carss & Bell, 2006, to name a few. Having thoroughly reviewed both theoretical and empirical literature on interdisciplinarity and collaboration, a deliberate decision has been made in this study to group these factors and conditions into distinct clusters of determinants in order to provide a systematic discussion, and to eventually come up with a process model for interdisciplinary collaboration. This section hence is, first, intended to identify the primary determinants of collaborative efforts. Then, the intention is to solve the puzzle of dynamic collaborative processes in interdisciplinary research teams by closely looking at the progress of collaborative learning.

With regard to a more general overview of collaborative IDR, several themes, having a positive impact on interdisciplinary work, emerge from the literature. They include, for example, respect for scientific process and identifying interesting topics (Aboelela et al., 2007). Also, what concerns a group level, Billups (1987) explored the dynamics of inter-professional teams, and suggested that interaction within the group has democratically-oriented attributes, such as “free participation, reasonably full participation, and a sufficient level of agreement to lead to a concerted series of collective decisions and actions” (p. 148). Furthermore, an interesting insight has been made by Olson and Olson (2000) in relation to cross-disciplinary collaborative teams that are geographically dispersed. The authors focused on to the expectation of such groups to communicate easily with each other: video conferencing practice is nowadays supposed to enhance communication between distant collaborative teams, and to mark the ‘the death of distance’. Nevertheless, Olson and Olson (2000) counter-argued by saying that with all emerging information and communication technologies, distance is not only alive – it is immortal, and affects humans’ interaction with one another. In addition, they emphasized the importance of technological readiness, as well as the extent, to which team members can access the requisite technical infrastructure and possess sufficient expertise for engaging in digital communication and information exchange (Hall et al., 2008). That is what Olson and Olson (2000) call “collaboration readiness”, and note that one should not attempt to introduce groupware and remote technologies in organisations and communities that do not have a culture of sharing and collaboration, but should instead align incentive structures to the desired behaviour, if more knowledge is to be shared.

A closer look to the literature suggests a more specific grouping of the factors and circumstances that influence team-work. For instance, Hall et al. (2008) named these as “collaborative-readiness factors”, and put them into three categories – contextual-environmental conditions, intrapersonal characteristics, and interpersonal factors. Based on this classification, as well as on other multiple attempts by other authors – Bronstein, 2003; Van den Bossche et al., 2006; Hall et al., 2008, four clusters of factors and conditions of a distinct nature, relevant to collaborative teams, are further presented and discussed in detail.

Professional factors

The first cluster of factors includes professional characteristics of researchers, taking part in large scale IDR collaborations. Disciplinary and professional background are essential contributors to interdisciplinary collaboration. They are also composite elements of an individual professional identity that affects the way people interact with one another. In particular, professional or disciplinary background, as well as accumulated professional and interdisciplinary experience in IDR, closely relate to the value – either high or low – each researcher assigns to an autonomous application of discipline-specific theories, models, and approaches to the solution of an issue in question (Bronstein, 2003). In this sense, professional characteristics may make the traditional disciplinary division between people more evident in practice, also making researchers prone to show the strengths of their accumulated professional knowledge over others'.

Nonetheless, to identify the division between people due to their professional differences is not to deny the opposite power a professional role has in promoting collaboration through "reciprocal respect regardless of the profession's status in the setting" (Bronstein, 2003: 303). In other words, a multi-professional composition of IDR team could suggest that such teams are likely to develop a higher degree of respect of researchers to other than their own disciplines, unlike less disciplinary diverse groups. The reason why is that in fulfilling a given task, researchers acknowledge some certain degree of interdependency within a team, and hence aim at hearing out the arguments of and ideas from other disciplines. Conversely, low disciplinary diverse IDR teams, from a professional standpoint, may be less inclined to actively involve different than dominating disciplines into collaborative processes, and so grow them over. Granted, professional type factors suggests two most evident items, derived from the literature.

The first one is disciplinary background of participating researchers. Given the nature of a question that a temporary IDR team has to deal with, the composition of researchers within the group will be determined. In that sense, the more transdisciplinary the issue is, the more disciplinary boundaries it transcends, and, thus, a higher number of various disciplines are to be involved in scientific interdisciplinary collaboration.

As a matter of fact, different scientific disciplines have specific characteristics. So as to overcome the complexity of categorisation of them, Van Rijnsoever and Hessels (2011) came up with an idea to distinguish between 'basic' and 'strategic' types of disciplines, based on the degree of their concern with application. Henceforth, chemistry or physics fall under the basic type of disciplines, being relatively autonomous in developing the knowledge about a subject matter, whilst medicine, informatics and pharmacy, according to the authors, would represent the strategic type of disciplines as they are much more closely related to practical knowledge application in solving human problems. In addition to this, what concerns the link between the diversity of disciplines and interdisciplinary collaboration endeavours, the research has shown that the degree of collaboration in particular fields varies across disciplines – researchers working in strategic disciplines engage in IDR collaboration more often than researchers from basic disciplines (Van Rijnsoever & Hessels, 2011). Moreover, the type of IDR may also be determined by a scientific discipline, specific to the participating researcher – Porter & Rafols (2009) found out that the average share of interdisciplinary citations differs namely per discipline.

The second professional factor is interdisciplinary experience of researchers that refers to previous professional experience in IDR projects or initiatives. If participating scientists have already participated in the project(s) of interdisciplinary nature prior to their current IDR occupation, would positively influence their personal performance and orientation towards interdisciplinary collaboration with other researchers. In fact, empirical evidence proved this by showing that researchers with previous work experience, related to interdisciplinary initiatives, are more inclined and committed to collaborative IDR (Van Rijnsoever, 2011).

Individual factors

The second cluster comprises individual characteristics of researchers, taking part in larger-scale IDR initiatives, which cover both personal characteristics, as well as inclination to engage in the collaborative endeavour, from a personal standpoint. Similarly as a professional identity, personality factors shape individual behaviour in the context of inter-scientific collaboration, so, a range of personal characteristics have been identified as drivers of desired course of IDR collaboration. Hence, individual factors, selected from past research and to be investigated further in this research are *personal willingness* and *flexibility*.

First, 'willingness' is widely discussed in the literature on both IDR and collaboration, although a clear-cut definition of it as a collaboration determinant is seemingly missing. Nonetheless, to make it more clear, willingness can be perceived either in terms of personal motivation or professional gains. In the first case, willingness can be defined as a pre-determined personal inclination to make interdisciplinary collaboration work. More specifically, that would require researchers to have a genuine interest in a topic or an issue in question, otherwise personal focus on a topic over the course of a project might eventually die out, leaving the researcher with mainly technical fulfilment of his/her tasks. In the case of willingness in terms of professional gains, researchers who are willing to engage in IDR projects, may be characterized as being personally oriented towards learning from other disciplines, and enhancing their accumulated knowledge. Moreover, willingness can be closely related to an inclination to contribute to achieving the IDR project outcome(s). Finally, the most often incentive behind IDR projects for participating researchers is the opportunity to expand their own professional network. Empirical evidence shows that the longer researchers have been active in terms of their professional career, the more likely they are to build professional networks (Van Rijnsoever, 2011).

As indicated, both personal motivation and professional gains, constituting *willingness* as one of the individual type of drivers of interdisciplinary collaboration, are mainly perceived as pre-determined personal expectations. Nevertheless, the literature suggests an alternative interpretation of willingness as a "bridge building skill" (Marzano, Cars & Bell, 2006: 193). In this case, it represents personal commitment of a researcher, as well as inspiring one's colleagues to act likewise. As such, willingness is of a paramount importance to the outcome(s) of IDR teams because it contributes to the overall social context, in which team learning behaviour develops. Thompson (2009) found out that the lower the amount and types of outside resistance of members in IDR teams are felt, the higher the individual willingness of participants to engage in collaborative endeavour will be. In other words, if IDR colleagues show some resistance toward

collaborative team-work, or if their absence is often, the individual willingness to contribute to IDR initiative decreases, directly disturbing the overall atmosphere. Therefore, willingness is not only pre-set expectations for both personal and professional gains of individual researchers, who are about to take a role in IDR collaboration, but also a dynamic state of mind of participating individuals.

Second, the factor that is well-discussed in relation to individual characteristics in the literature is 'flexibility'. Unlike in the case of willingness, which is more connected to individual expectations, flexibility relates more to an organisational setting of the project. In other words, flexibility is expressed in the extent, to which researchers adapt to the working environment, different to that usual to them. Team colleagues would seemingly be open to varied or new ways of working (Mattesich & Monsey, 1992), whether these would be, for instance, field trips, closed official meetings, or general assemblies of all participating colleagues. Also, researchers easily adapting to given time frames and tasks within the project would also be considered as flexible. Generally, personal flexibility in relation to an organisational structure ensures researchers of IDR teams feeling not disturbed by any changes, occurring during the course of the project, and allows them feel comfortable with a new direction of a project, or an organisational setting.

Organisational structure

In addition to professional and personal factors, a number of organizational and structural conditions facilitating IDR are prevalent in the literature. Multiple structural factors and conditions, as well their combinations to a varying degree may affect the course of interdisciplinary collaboration. Hence, the main question is whether an organisational structure fosters interaction among participating project partners.

Bronstein (2003) contributed to the empirical findings in this respect, indicating that manageable caseload, administrative support, and, most importantly, agency culture, which supports collaborative work, have a strong impact on the success of collaborative work. Furthermore, Billups (1987) introduced several inter-professional sub-processes, leading to collective ownership of goals in collaborative teams. To mention the ones relevant to this study: "achieving a sound professional identification" is mainly related to defining and re-defining roles of participants throughout the whole process of collaboration; another one comprises several elements: "identifying and assessing problems to be addressed, setting goals, and developing action plans", and may potentially lead to far-reaching desired consequences; ultimately, "negotiating and implementing the action plan" refers to critical processes, if collaboration is to run its complete course successfully (see p. 148-150). Finally, sufficient institutional resources are also of high importance during the course of IDR collaboration (Aboelela et al., 2007). Counting on these insights, three although often interdependent, but presumably separate determinants are distinguished further.

The first is *joint activities*. The discussed dynamics of collaborative relationship requires IDR teams to be active in collaborative processes, and, thus, conditions set by organizational structure for all participating researchers would ideally be equal in order to ensure their inclusion in the joint activities. A particular concern of being equally involved in discussions and research efforts has been expressed in the research of Marzano, Cars & Bell (2006) by members of IDR team. So as to ensure the concern is met, definite channels

are to be established, enabling the interaction among people, tied with collaborative relations (Hord, 1986). Either formal or informal these channels are, the core idea behind the creation of them is to make IDR teams spend at least some time together because collectively spent time is "the first requirement for team building and developing communication competence" (Thompson, 2009: 285). Moreover, any kind of joint activities ensure the cohesive flow of information within and among teams, which is essential to IDR collaborations, and they even establish personal connections (Mattesich & Monsey, 1992).

Granted, Bronstein (2003) named any kind of joint activities in collaborations as 'interdependence' in terms of interaction among professionals, "whereby each is dependent on the other to accomplish his or her goals and tasks" (p. 299). Characteristics of interdependence, according to the author, include both formal and informal time spent together, as well as oral and written communication among colleagues. In addition, it is empirically evident that workshops, fieldtrips, and social occasions are of the highest influence joint activities in social collaborations during which not only formal, but, essentially, informal discussions unfold, often strengthening interpersonal relationships (Marzano, Cars & Bell, 2006). In addition, Van den Bossche et al. (2006) concluded that joint activities of any kind not only promote a reciprocal sense of ownership and responsibility among IDR members, but also establish some sort of group identity, which in the long run materialises in a shared team cognition.

Essentially, as a progress of scientific knowledge integration is central to the present study, Klein (1990) has emphasized that synthesis of knowledge is primarily to be achieved through core meetings, seminars, and various workshops, and, more importantly, such ongoing and systematic communication of IDR partners "lessens the likelihood of shortfalls of integration" (p. 119).

The second factor representing organisational conditions for IDR projects is *having enough time* for both fulfilling personal and team tasks, as well as for meaningful discussions and negotiations among IDR partners. IDR collaboration is likely to be time-consuming as collaborators not only aim at learning about each other's roles and from their disciplines, but also tend to elaborate on their own ideas with their colleagues, and to explore each other's arguments (Bruner, 1991; Hall et al., 2008; van Meerkerk & Slob, 2013). If compared to cooperation, collaboration necessitates a greater amount of time because activities are shared, and to be accomplished through mutual efforts of participants, rather than allowed, as in cooperative endeavours (Hord, 1986).

Collaborative teams comprise a wide range of personalities, as well as various disciplines, and frequently different interests of participants on top of that. Particularly temporary teams often do not have a sufficient time frame to engage neither in the usual forms of confidence building activities that contribute to developing trust among individuals (Meyerson, Weick & Kramer, 1996), nor sometimes even in the very basic discussions and negotiations about the content of the project. In that sense, "if a group is pushed too quickly toward integration, the crucial activities of building rapport and exploring ways to understand how each discipline approaches a research question are short-changed, ultimately short-changing the quality of the integration" (Klein, 2008: 120), and eventually leaving team members frustrated (Thompson, 2009). Therefore, having just enough time for discussions, hearing each other's thoughts and ideas seems to be

crucial for the success of temporary teams as not only it provides a foundation for collaborative learning, but sometimes also highlights the misunderstandings or different viewpoints, meaning that even more time needs to be devoted (and given by the project management) for the alignment of the divergent opinions (Thompson, 2009; Marzano, Cars & Bell, 2006).

The third organisational factor is two-fold: it includes clear tasks and roles of researchers participating in IDR projects, as well as goals to be reached at the end of collaborative initiative. That is why collaborative teams not only have to spend time together on establishing and improving relational opportunities to engage in a team-work, but also to practice task and goal talks so as to clarify the duties, responsibilities and the main aim of the project. That is not to deny the need to have the tasks and goals clarified by the managers of the project, who should also devote a substantial amount of time for defining and explaining the context, ideas, objectives, tasks and goals of the project to their teams.

In fact, clearly knowing your own role and responsibilities within the project, as well as understanding the main objective of the initiative, shapes the way the group work is evolving, and realistically enables IDR members to achieve the goal, which otherwise is highly unlikely (Mattesich & Monsey, 1992). Furthermore, from a collaboration perspective, unlike in cooperative relations, people commit to exchanging tasks, and join their forces to execute the design of a joint project. Therefore, "the necessity for clarifying expectations of tasks and goals of the participants is of paramount importance" as "goals provide the congruity to the effort" in a collaborative environment (Hord, 1986: 25).

To sum up, all three structural factors – joint activities, enough time, and clear tasks and goals, are more of an early-stage starting conditions, enhancing understanding and collaboration among disciplines (Marzano, Cars & Bell, 2006). Nonetheless, continuous elaboration on them is also an integrative part of the process of a purposeful collaborative work. Thus, sustained devotion of time and resources to an active participation in collaborative work by both IDR members, as well as by the project management benefits the team in the long run (Thompson, 2009). Generally, all three conditions of organisational structure are likely to minimize the likelihood of things going wrong during IDR initiative (Meyerson, Weick & Kramer, 1996).

Managerial strategies

As attempted to show, interdisciplinary collaboration process unfolds not based on a pre-determined project plan, but rather during reciprocal interaction among scientists of a temporary IDR initiative. Nevertheless, research has demonstrated that "appropriate leadership can enhance the overall effectiveness of teams and increase the satisfaction of team members" (Gray, 2008: 125). So, the project management may undertake a critical role to some extent in shepherding interdisciplinary endeavours. A wide range of collaboration barriers potentially impede collaborative endeavours, thus, the question of how well the management of the project implements its role in facilitating consensus building over the life-course of the IDR initiative is of high relevance to this study.

Having extensively studied the literature on collaborative IDR in practice, three different types of leadership tasks can be distinguished. Deliberate distribution of managerial focus might be referred to as "dispersed leadership" that is specifically characteristic to IDR endeavours (Hord, 1986).

The first type of management, essential to organising collaboration across science-science boundaries, is *structural strategies*. They "address the team's need for coordination and information exchange" either within or among teams, and may potentially "enhance team's overall performance through the creation of social capital" (Gray, 2008: 126-127). In IDR projects, a large scale effective dialogue between the participants is time consuming, and requires actual inclusion of all partners, instead of expecting it to 'just happen' (Marzano et al., 2006). For this reason, project management is presumably the primary source of appropriate organisational source for uninterrupted interdisciplinary collaboration from the early to the later stages, in order to provide enough time for joint activities to materialise in a shared cognition and mutual agreement among researchers on given issues. Moreover, structural management tasks may involve stimulating interactions among various groups within the project, as well as the exchange of information among relevant participants. In this sense, a coordination of different inputs and deliverables of the work groups could be facilitated by the project leaders. Ultimately, a role of clarifying both the tasks and goals within and among the teams, for instance, modules and/or work packages within the project is equally important. The creation of collective ownership of tasks and goals hence may be achieved among participants, if the management, first of all, identify the issues to be addressed and the tasks set in relation to these issues; and, second, engage in negotiating with project members on the implementation of the action plan, as well as facilitate the following steps of arriving to the common goal (Billups, 1987).

The second type of management tasks is *processual strategies* that mainly "include a host of activities related to ensuring that the interactions among team members are constructive and productive" (Gray, 2008: 127). As "collaboration involves sharing responsibility, it requires consensus-building and may not be imposed hierarchically" (Bruner, 1991: 6). Therefore, managerial activities, undertaken by project and/or meeting managers may serve as facilitating the process, leading an IDR team toward a desired goal. As such, in the context of the present study, the management of IDR meetings plays an important role: IDR teams could benefit from the use of a professional meeting facilitator, which could "help the team to manage negative aspects or the dark side of communication competence", which otherwise would not be likely to be confronted by the team itself (Thompson, 2009: 296). In particular, several tasks fall under the umbrella of managing meetings: listening to the inputs of different disciplines, and making sure that each of them gets enough room for having its say. Also, building an informal atmosphere among participants, as well as building trust among them so that the interaction between disciplines could intensify. These and other related processual tasks may eventually "lessen misunderstandings, and strengthen the conditions for consensual modes of work" (Klein, 2008: 119).

Third, the most important task of management for this study is *cognitive or knowledge integration management strategies*. These involve "the management of meaning" by introducing mental maps of desired goals and methods for the achievement of them (Gray, 2008: 125). Cognition in this respect is defined as "structured or organised knowledge that aids a person in interpreting" various matters (Emerre, 2013: 55).

In addition, Thompson (2009) ironically emphasized scientific expertise typically being excellent, albeit the communication of scientific experts is usually poor due to the lack of effective management of the knowledge they have, and their collaboration processes. In that sense, meeting managers may undertake a role of knowledge integration management so as to align self-concepts and individual scientific inspirations with the larger IDR mission (see Gray, 2008: 125-126). The practical way to ensure this is to engage in boundary spanning activities that are essential for linking groups of actors that are otherwise not connected in terms of their disciplinary mind-set. "A major obstacle in IDR is that it is difficult to find a common language because of disciplinary specialization" (Thompson, 2009: 286), so, boundary spanning is crucial in terms of clarifying language differences between team members, as well as between the teams. Differences in concepts, theoretical approaches, methods, prior research experience and other similar aspects lead scientists with diverse disciplinary background to miscommunication, and may determine stalemates in further collaborative processes. Therefore, cognitive management is likely to enable meeting managers to publicly address the need for knowledge integration, and even challenge participants to cross their disciplinary boundaries. That is to say that project managers, as well as team leaders by engaging in connecting activities may induce effects, expediting collaboration within the project.

Team factors

High importance in the empirical research is assigned to certain team factors, which are fundamentally of a social nature, and develop through the communication – discursive collaboration, once a temporary collaborative teams have been formed (Aboelela et al., 2007; Van den Bossche et al., 2006; Bruce, Lyall & Tait, 2004). The first team factor, distinguished in the literature, is case-specific social context that emerges as a consequence of having established a multidisciplinary team. It is frequently referred to as *atmosphere* within temporary collaborative teams. A closer analytical look at atmosphere hence would indicate, whether researchers feel comfortable during their interactions with collaborating colleagues, and especially, whether people believe their colleagues are willingly listening to others' contributions. Moreover, presumably more positive atmosphere prevails in IDR teams, when participants think they have enough time to engage in discussions with their colleagues. Theoretically, the interactions of team members are positive when they help people to get to know each other better, and make them feel comfortable in showing limits of their own knowledge to others during the discussions. Such social context, consequently, influences team socio-cognitive processes and further team learning, rather than occurs in a vacuum (Van den Bossche et al., 2006). It may also nourish researchers' willingness to pursue joint collaborative efforts (Barron, 2003).

Second team factor, broadly elaborated in the literature on collaboration, is *challenges,* to which IDR teams get exposed, when engaged in inter-cooperation. Often, such issues are related to unclear roles of actors, their functions, and project mission(s), also, to clashes of personalities and their background or previous interpersonal experience, or the status difference between the various professions (Corney, 1989, Bronstein, 2003). Further, one of the main obstacles to interdisciplinary collaboration stems from an inherent division between academic disciplinary fields. Not only conflicts, but also competition of a high level is inherent to collaborative IDR teams, both hindering good-will collaboration: although domain-specific knowledge is

identified as an important determinant of excellent performance across many different disciplines, it might also aggravate the process of achieving scientific knowledge synthesis (Van den Bossche et al., 2006). Moreover, one of the main barriers to interdisciplinary collaboration, closely related to an organisational structure of IDR initiatives, is not having insufficient time for aligning the sharp-edges of disciplinary fields discussing the topic, and especially the issues, related to both diverse definitions and solutions of an issue in question (Hord, 1986; Bronstein, 2003). Next, absence of process skills, such as decision making and problem solving, also, information exchange coordination, and boundary management, are also noted as a crucial detriment to collaboration (Gray, 2008). Finally, past research also indicates that "negative humour, debating expertise, communicating boredom, and power struggles" are inevitable to IDR teams, and should be handled before they become group norms (Thompson 2009: 295-296).

Third, the success of collaborative teams depends on the bonds that tie people together, and the main of these is *trust* (Marzano et al., 2006; Mattesich & Monsey, 1992). "As a variable (…) trust is quite complex" (Thompson, 2009: 285), and collaborative teams working on temporary projects, according to Meyerson, Weick and Kramer (1996), develop "swift trust" that has unusual properties (p. 167). The authors state that trust that develops in temporary collaborative initiatives is of a unique form of collective perception that is capable of dealing with four types of issues – vulnerability, uncertainty, risk, and expectations. If these are not managed by trusting behaviour, they leave participants in a permanent crowd, rather than in a temporary collaborative team. In addition, Kramer (2010), saying that the benefits of trust within collaborative organizational arrangements are extensively discussed in the existing literature, confirmed the previous research: "a well-documented relationship exists between individuals' trust in other people and their willingness to engage in trust-related behaviour when interacting with them" (p. 83). As a result, being actively involved in IDR initiative, scientists are likely to develop personal trust, also, trust in institutional arrangements (organisations and contracts), and trust in institutions (formal and informal rules) (Edelenbos, & Eshuis, 2012). Empirical evidence shows that a more personalised form of trust can even improve both process and content outcomes of the project (Klijn, Edelenbos & Steijn, 2010). Moreover, in large scale collaborative networks actors are to develop process-based trust that also serves as a regulatory mechanism, during which the network actors gain knowledge about the trustworthiness of their counterparts (Edelenbos & Eshuis, 2012). As such, uninterrupted interpersonal trust building is essential to collaborative teams in order to arrive at viable knowledge integration through interrelating with one another (Thompson, 2009; Meyerson, Weick & Kramer, 1996). Trust relations and collaboration process, thus, develop in a reciprocal manner: "positive expectations about others facilitate positive behaviours, when interacting with them; those behaviours, in turn, strengthen positive expectations; hence, a virtuous cycle, in which expectation and action collude to create and reinforce desired outcomes" evolves (Kramer, 2010: 83).

Fourth, a tendency of maintaining *conflicts constructive* within IDR teams is important. Given the complexity of collaborative IDR teams, misunderstandings are likely, when often disparate disciplines are brought together to work on a complex issue: "squabbles about the validity of each other's conceptual frameworks, mismatches between rewards stressing disciplinary competence over innovation, and institutional disincentives" are potential barriers to smooth collaborative development of IDR teams toward successful

interdisciplinary work (Gray, 2008: 125). Moreover, various sources of disagreement or interest divergence are highly likely to emerge during IDR initiatives, requiring various trade-offs to be arranged. Klein (2008) suggested managing such trade-offs in "balancing acts that require negotiation and compromise" (p. 116), therefore, a "compromise is a necessity" (Hord, 1986: 25). The core idea behind the existence of divergent personal and scientific arguments is that they make IDR teams stay actively engaged in continued discursive collaboration. Under these circumstances, theory assumes practices of constructive conflict resolution to emerge, which are defined as "negotiation of the differences in interpretation among team members by arguments and clarifications", leading to meaning divergence (Van den Bossche et al., 2006: 496). Hence, an integrative part of constructive conflict is the "ability to make mistakes gracefully" (Aboelela et al., 2007: 334). So, if IDR teams maintain constructive conflict, mutually shared cognition is likely to develop.

2.4. Conceptual framework for the research

2.4.1. Building a two-part model

In recent years, "increasing attention has been devoted to the social bases of cognition, taking into consideration, how social processes in groups and teams affect performance" (Van den Bossche et al., 2006: 490). As mentioned before, numerous empirical studies have attempted to investigate multiple factors enabling (or to some extent hindering) interdisciplinary work. Yet, very little scholarly attempts (Van den Bossche et al., 2006; Hall et al., 2008) aimed at exploring the process of team collaboration, during which scientific knowledge integration evolves. As a matter of fact, these studies contribute to the theory of interdisciplinarity with multiple findings only on single decisive factors, rather than empirically enhance development of team collaboration toward interdisciplinary learning. Having extensively discussed and distinguished the concepts of interdisciplinarity and interdisciplinary collaboration, as well as its determinants, the idea that interdisciplinarity generally is best understood as a variety of various ways of bridging and confronting prevailing disciplinary approaches, rather than as one thing (Huutoniemi et al., 2010) is conclusive in this research.

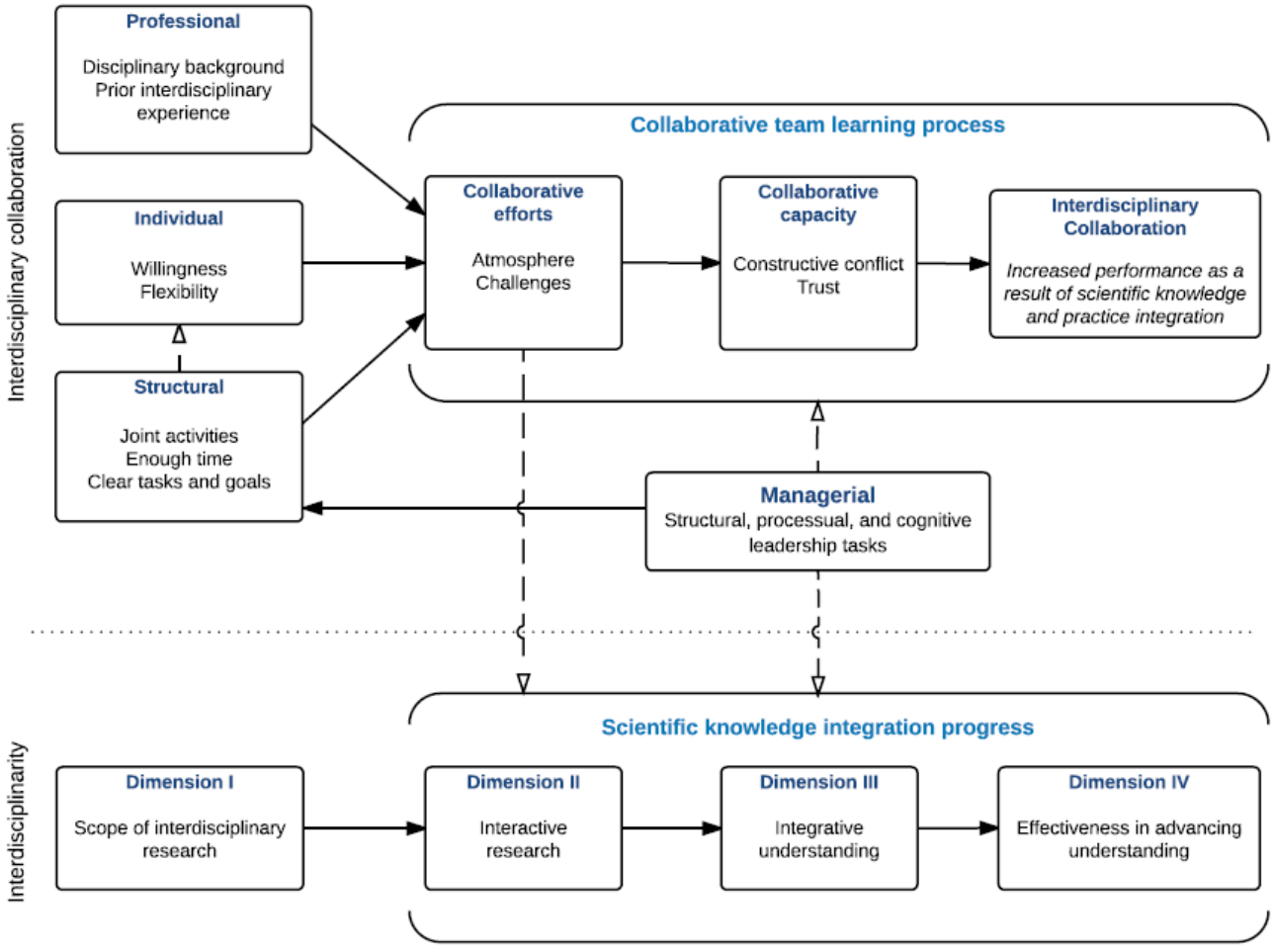
Having this in mind, deliberate choices have been made in this study to select the factors and conditions, which theoretically bear explanatory power in putting together and explaining a processual puzzle of interdisciplinary collaboration among researchers. Hence, four clusters of factors and conditions of different types constitute a two-fold conceptual model for this research, depicted in Figure 2 below.

The core idea behind building a two-fold model for capturing interdisciplinarity progress in the selected case is grounded in two reasons. First, multiple studies in various disciplinary fields explored numerous options for assessing knowledge integration in terms of various indicators as it is evident from the previous sections. Yet, no common indicator has been commonly accepted in the academia for the evaluation of a progress of scientific knowledge integration in a certain time frame. To the contrary, the way interdisciplinarity is approached in this study provides a new theoretical insight on interdisciplinarity by distinguishing four consequent dimensions with characteristic earmarks, enabling tracking a progress of scientific knowledge integration in IDR initiatives. Second, a better understanding of the underlying socio-cognitive processes of

interdisciplinary team-work may provide an explanatory projection into which exact type of factors and conditions hold an influence on a progression of interdisciplinarity. Hence, by analysing social collaboration among project partners can potentially allow having a much closer look at the relational processes within the IDR team learning process.

Having combined both reasons, a multi-component two-fold model is to be employed as a guidance in carrying out the analysis in this research. The *forte* of this model is in its dual-focus on interdisciplinarity progress, and the process of interdisciplinary collaboration, during which the evolution of scientific knowledge integration is likely to emerge. Henceforth, the discussion on the relationships between the composite elements of the model are further detailed.

Figure 2. Two-fold conceptual model for the research



Source: Developed by the author, based on the theoretical framework of this study

2.4.2. Discussing the composite model elements

At the bottom of the model, four dimensions of interdisciplinarity, defined in section 2.1.2., are positioned. They represent more of a *content component* of the model, which in most of IDR initiatives is the core focus. A progress of interdisciplinarity, as presupposed earlier in this study, unfolds in a consequent manner with ever-increasing degree of scientific knowledge integration, until it reaches ultimate interdisciplinary learning phase. As the model indicates, the relationship between the managerial strategies and knowledge integration progress has been set. The reason derives from theory that managers of IDR initiatives is often exposed to a dilemma of managerial choices of prioritising either the content or the process within the project. As a result, the facilitation by project leaders is expected to have an impact on knowledge integration progress.

At the upper part of the model, the ideal processual pathway toward interdisciplinary collaboration among researchers is illustrated, and represents more of a *process component* of the model. For solving the processual puzzle, concept mapping has been invoked, based on one of the generic elements suggested by Klein (2008) for measuring interdisciplinarity: "interaction of social and cognitive factors in collaboration" (p. 116). As such, the mapping process included clustering a range of different factors and conditions prominent in the literature, and setting their relationship with three stages of collaborative team learning process, based on a systemic study of the literature. To detail, the first two clusters in the model represent professional and individual factors respectively, which are expected to hold an influence on the collaborative team learning behaviour. Similarly, the third cluster – structural factors and conditions – is also expected to have an impact on the collaborative team learning, and, at the same time, to be affecting individual factors, such as willingness and flexibility. Furthermore, the fourth cluster represents managerial strategies of processual, structural, and cognitive types, and is equally seen as having an impact on team collaboration process. In concert, all four clusters of factors and conditions put the collaborative team-work in context, in which collaborative team learning process starts and develops further in a consequent manner through three evolutionary stages: collaborative efforts, collaborative capacity, and interdisciplinary collaboration. As it has been discussed, each of the stages is characteristic, and reflects the inner socio-cognitive features of IDR teams (see section 2.2.2.).

As it is evident in the model, collaborative team learning stages conform to the three dimensions of interdisciplinarity progress, and are likely to accord with gradually evolving collaboration. That is no accident – they are rather mutually reinforcing approaches to IDR. On one side, interdisciplinarity is a certain degree of scientific knowledge integration at a particular moment in time, from a perspective of a cross-disciplinary research, whilst, on another side, interdisciplinary collaboration is, from a perspective of a collaborative team learning, a relational process, which reveals underlying arguments, bearing explanatory power of interdisciplinarity progress in IDR initiatives.

Altogether, the analysis of this study is to invoke the model as a guidance, so, the distinction amongst the two parts of the model is to serve as an orientation, rather than to mark a strict distinction in between.

2.4.3. Inherent model dynamics

According to Klein (2008), evaluating interdisciplinarity in reality "is shaped by multiples: multiple actors making multiple decisions in varied organisational settings with context-dependent measures of quality" (p. 117). This approach to interdisciplinarity reveals the inherent dynamics of collaborative IDR teams, and it has namely suggested the idea for the empirical exploration of the processual properties in the selected case to be analysed in this study. As such, although the conceptual model illustrates an ideal pathway toward both interdisciplinarity, and interdisciplinary collaboration, the analysis is likely to reveal non-linear relationships between the composite model elements, resulting in a more complex interplay.

To illustrate, theory suggests that all four dimensions of scientific knowledge integration require ever-greater degree of interaction between researchers (Aboelela et al., 2007), meaning that through the course from the initial to the later dimensions, the degree of interdisciplinarity is presumed to grow. Notwithstanding, the logic underlying interdisciplinarity progression might not necessarily happen in a linear manner in practice due to its dynamic nature. In that sense, the features of all four dimensions of knowledge integration may appear at one moment in time, suggesting that practical scientific knowledge synthesis simply does not obey theoretical presumptions. Moreover, four clusters of professional, personal, organisational, and managerial factors and conditions show only minor inter-relation in the model. Yet, in practice, dynamic reciprocal relationships between these and other variables from the collaborative team learning may become evident in the empirical analysis, as delineated further. For instance, pleasant social context (atmosphere) is likely to nourish individual willingness to engage in joint efforts (Van den Bossche et al., 2006), as well as it may discourage researchers from collaboration, if the organisational structure or meetings' atmosphere is uncomfortable. Also, certain challenges may hinder individual dedication to interdisciplinary collaboration, and vice versa. With regard to professional factors, they are deemed as affecting interdisciplinarity in a most unpredictable manner as disciplinary diversity is always case-specific, and fundamentally shapes interdisciplinary collaboration. Finally, what concerns the managerial strategies, in order to overcome disciplinary asymmetry of IDR initiatives, conscious project-specific leadership efforts are to be undertaken. Instead of following a pre-determined plan, project leaders or meeting managers may engage in connecting activity, which may help transcending personal, professional, and disciplinary boundaries. In that sense, managerial touch on aligning the content and process trajectories within the project is likely to be adjusted to team-specific development and atmosphere. Various managerial facilitation, thus, may become apparent in any stage of IDR collaboration.

Altogether, the above discussed, and alternative reciprocal inter-relation among the factors and conditions figuratively prove the inherent complexity of collaboration in IDR teams.

Chapter III: Research design

This chapter will start of by discussing the role of the conceptual model in the research. The way the two-part model is to be measured will then be elaborated, including the operationalisation of independent and dependent variables, constituting the model. A summary, indicating what method is to be employed in measuring certain variables will be provided in addition. Third, an extensive discussion on the methodology will follow, broadly introducing the case study research design, to be applied in this study. To specify, the section will detail a mixed-method of data collection, as well as the samples and participants of both quantitative survey and qualitative interview methods. Both internal and external validity of the research will be lastly substantiated.

3.1. Role of the model in the research

Building upon the conceptual model, its role in this research necessitates brief, yet explicit elaboration. A genuine interest in exploring how collaborative IDR initiatives facilitate the progress of scientific knowledge integration in this study raises a question of how individual cognitive capabilities and other types of factors become aligned and integrated on an interpersonal (group) level. An initial empirical objective, thereby, has been set to identify the socio-cognitive properties, to which IDR partners are exposed to during the collaboration with other researchers, as well as to look at how interdisciplinary partnerships affect the degree of interdisciplinarity in the project. In particular, having extensively discussed the distinction and the propinquity of both concepts – interdisciplinarity and interdisciplinary collaboration, the core ambition of this study is to investigate whether Globaqua has succeeded in a progression of interdisciplinarity so far, and how interdisciplinary collaboration of the Globaqua researchers in practice can explain this evolution.

In order to do so, instead of testing one indicative theory, this research aims at unveiling the relationship between the composite elements of the conceptual model, as well as at seeing, how close (or how far) the collaborative IDR team of Globaqua is in relation to theory, broadly elaborated in the theoretical framework of this study. With this in mind, a two-fold conceptual model, depicted in Figure 2, is to be invoked as a theoretical guideline for the empirical analysis, and is to serve as a heuristic tool for exploring the complexity of both the evolution of IDR, as well as of a dynamic interplay of the constitutive elements of interdisciplinary collaboration – four different clusters of factors and conditions in relation to team factors. Granted, this research will follow an in-depth case study research design, in which both quantitative and qualitative data collection methods are to intertwine (for more, see section 3.3.).

To note, no hypotheses have been set to be tested in this study. Rather, by invoking the conceptual model as a guidance, mixed-method research design is expected to enable diving deep into the Globaqua case, and drawing solid explanatory findings on the overall picture of a progress of interdisciplinarity in the project.

3.2. Measuring the components of the conceptual model

3.2.1. Capturing interdisciplinarity

In this research, scientific knowledge integration will be primarily investigated in a quantitative manner. The data, collected through the survey questionnaires, will be of service in capturing interdisciplinarity progress in the context of the official Globaqua project meetings by following four steps of statistical data analysis.

First, the results will allow reviewing the mean scores on interdisciplinarity, based on the Globaqua participants' evaluations in three different types of project meetings. Second, having the evaluations from different meetings will enable comparing the scores between the same type of meetings, and hence observing the differences (if any). Third, by invoking various independent variables, such as *disciplinary background,* and *prior interdisciplinary experience,* some common trends in scoring on interdisciplinarity dimensions are expected to emerge. Fourth, a specific focus on the Module meetings will be put in relation to managerial facilitation by the Module leaders. In this respect, not only the relationships between the *managerial strategies* and interdisciplinarity dimensions are to be tested, but also the overall scoring in Module meetings is to be compared to the other types of Globaqua meetings. Having done all, the statistical analysis results are expected to capture the progress of interdisciplinarity in Globaqua meetings, and to some extent provide explanatory arguments, supporting it.

Also, through the process of carrying out the quantitative analysis in accordance to the structure above, additional relationship between *knowledge integration* and *atmosphere,* as well as between *challenges* will be investigated. The latter two factors are covered by the survey questionnaires, which enables statistical testing of their relationship with interdisciplinarity in Globaqua meetings. The results are expected to serve as an empirical proof for tracing the factors and conditions, influencing interdisciplinarity in Globaqua, in addition to the qualitative analysis.

Overall, the quantitative part of the empirical analysis in this research is aimed at allowing the researcher draw some generalising remarks that will be later compared and somewhat justified by the results from the interviews data in the second part of the empirical analysis in this study.

Operationalising interdisciplinarity

As it has been already introduced, interdisciplinarity progress in this study is defined in terms of four dimensions – scope of IDR, interactive research, integrative understanding, and effectiveness in advancing understanding (see section 2.1.2.). The constructs have been developed prior starting this research, mainly based on the framework for evaluating IDR, introduced by van Meerkerk & Slob in the ARCH report (2013), and partly by adjusting the measures from the earlier studies on a cross-disciplinary research (Gray, 2008; Masse et al., 2008; Hall et al., 2008; Thompson, 2009; van Meerkerk & Slob, 2013). Hence, the operationalisation of the four interdisciplinarity dimensions is presented in Table 2 below.

Table 2. Operationalisation of interdisciplinarity

Dimensions	Nature	Items
Scope of interdisciplinarity	Independent variable	Overall number of participating disciplines A number of different types of disciplines participating in the project
Interactive research	Dependent variable	A lot of interaction between different disciplines is present in Globaqua Much time is spent on understanding different disciplines in Globaqua Research methods from different disciplines are integrated in Globaqua Theories and models from different disciplines are integrated
Integrative understanding	Dependent variable	Globaqua has helped in developing a common understanding up until now Globaqua has helped in developing shared concepts between the disciplines up until now Globaqua has helped in developing shared framework between disciplines up until now
Effectiveness in advancing understanding	Dependent variable	Interdisciplinary research among Globaqua participants leads to valuable scientific outcomes for river basin management that would not have occurred without collaboration The benefits of interdisciplinary research within Globaqua outweigh the inconveniences and costs of such work Globaqua has helped in learning from other disciplines Globaqua has improved one's appreciation of other disciplines Globaqua has improved one's integrative understanding of water issues

Source: Developed partly by the author, and partly based on the framework of van Meerkerk & Slob (2013)

3.2.2. Capturing interdisciplinary collaboration

Given the complexity of interdisciplinary collaboration, the process is to be investigated in a qualitative manner to enable diving deep into the case of Globaqua project, and taking a closer look at social interactions among the participants. Generally, a qualitative interview data analysis aims at achieving three objectives.

First, to build upon the quantitative analysis results, when investigating the perception of the interviewees on interdisciplinarity and its progress in Globaqua. Having the individual responses will enable making comparisons in between, as well as to some extent justifying uneven evaluations of interdisciplinarity, observed in the completed questionnaires. Second, to provide a substantial discussion on the factors and conditions of different types, enhancing (or hindering) interdisciplinary collaboration (and interdisciplinarity thereby), based on the first-hand experience of the interviewees. The aim here is to test, whether the responses during the interviews acknowledge the importance of the factors, deliberately chosen for the conceptual model, and to reveal other determinants that may come to the fore during the discussion with Globaqua partners. Third, to identify the factors, explaining the Globaqua case in terms of interdisciplinarity progression. In addition to this, to see, whether Globaqua is undergoing a consequent team learning process, when processing the interviews data, as well as to test, if the stages of collaborative team learning, derived from the theory, can be actually observed in the Globaqua case.

Overall, rich explanatory findings are expected to be obtained as a result of the qualitative part of empirical analysis, and to contribute to answering the research questions conclusively.

Operationalising interdisciplinary collaboration

Process of interdisciplinary collaboration in this study is approached from a relational perspective, and is seen as unfolding in three consecutive collaborative team learning stages. This process is influenced by four case-specific clusters of determinants: *professional, personal, structural*, and *managerial*, which can also be interpreted as initial conditions for interdisciplinary collaboration. As such, they represent independent variables, meanwhile, collaborative team learning represents the dependent variable in this research. Characteristic features of all the conceptual model components have been thoroughly described in the theoretical framework, based on which their operationalisation is provided in Table 3 and 4 respectively.

Table 3. Operationalisation of independent variables of interdisciplinary collaboration

Cluster of factors and conditions	Independent variables	Items
PROFESSIONAL FACTORS	**Disciplinary background**	A range of different disciplines (Physical sciences, Life sciences, Environmental sciences, Engineering, Social sciences, Humanities, and other)
	Experience in IDR	An expression in terms of years
PERSONAL FACTORS	**Willingness**	Showing personal interest in the topic and/or issue in question Having a personal interest to engage in interesting and enriching discussions with collaborating colleagues Being inclined to contribute to achieving the project objectives Having the aim to expand one's professional network
	Flexibility	Easily adapting to the set time frames for delivering one's tasks Easily adapting to a given role and task(s) within the project Feeling comfortable with any organizational and/or structural changes during the course of the project
STRUCTURAL FACTORS	**Joint activities**	A range of formal and informal joint activities in Globaqua, enabling communication and contact between project partners
	Enough time	Having enough time to fulfil their tasks Having enough time during Globaqua meetings to discuss issues with their counterparts
	Clear tasks	Knowing one's own tasks in work package(s) he/she is involved in Knowing one's group task in the module he/she works in
	Clear goals	Clearly understanding the main goal(s) of Globaqua project Understanding the added value of Globaqua outcomes to be achieved
MANAGERIAL STRATEGIES	**Structural management**	Module manager is stimulating interaction across work packages within the module Module manager is setting deadlines Module manager stimulates information exchange among participants Module manager is coordinating the different inputs and deliverables of the work packages
	Processual management	Module manager is listening to the inputs of the different disciplines Module manager is making sure that every discipline gets enough room for having their say Module manager is having a feeling for the different disciplines involved Module manager is respecting the different disciplines involved

		Module manager is focused on building an informal atmosphere among participants Module manager is focused on stimulating interaction between different disciplines Module manager is focused on building trust among participants
	Cognitive management	Module manager is focused on visioning Module manager is addressing the need for knowledge integration across different disciplinary boundaries Module manager is focused on aligning participant's individual scientific aspirations with the Globaqua mission Module manager is challenging participants to cross their disciplinary boundaries

Source: Developed partly by the author, and partly based on the framework of van Meerkerk & Slob (2013)

Table 4. Operationalisation of the dependent variables of interdisciplinary collaboration

Custer of factors	Dependent variables	Items
COLLABORATIVE TEAM LEARNING PROCESS	**Atmosphere**	Atmosphere during the meeting was comfortable The other participants were willing to listen to my contributions There was enough time for discussing ideas with other team members The meeting helped me to get to know the other participants better I feel comfortable to show limits or gaps in my knowledge to the other participants
	Challenges	Conflicts between disciplinary perspectives on river based management are frequent in Globaqua There is a high level of competition among the disciplinary groups in Globaqua Collaboration between different disciplines has posed a significant time burden in my research for Globaqua Up till now, collaboration between different disciplines in Globaqua has not been productive
	Trust	Personal good-will trust Trust in institutional arrangements, such as organisations and contracts Trust in institutions, such as formal and informal rules
	Constructive conflict	Having a constructive negotiation on approach differences with other researchers when conflicts arise Arriving to compromises during the meetings with colleagues Sometimes having to make personal trade-offs in terms of disciplinary arguments and practices Admitting one's own mistake(s) in a joint work Admitting other's mistake(s) in a joint work
	Interdisciplinary collaboration	A mode of doing research, during which a reciprocal interaction through the feedback between project partners takes place for the purpose of aligning different disciplinary practices and scientific knowledge, also, advancing one's understanding of the topic in question, and ensuring that the perceived outcomes of the research are advanced, if compared to single efforts

Source: Developed partly by the author, and partly based on the framework of van Meerkerk & Slob (2013)

3.2.3. Measuring variables and exploring relationships: quantitative or qualitative methods

As a mix of quantitative survey and qualitative interview methods is to be employed in this study, a summary of which method(s) is to be applied in measuring the variables is provided in Table 5 below.

Table 5. Indication of the methods employed for measuring the variables in this study

Group of variables	Variables	Method for measuring
Scientific knowledge integration	Scope of IDR, interactive research, integrative understanding, and effectiveness in advancing understanding	Both quantitative survey and qualitative interview methods
Professional factors	Disciplinary background, and prior experience in IDR	Both quantitative survey and qualitative interview methods
Personal factors	Willingness, and flexibility	Qualitative interview method
Structural factors	Joint activities, enough time, and clear tasks and goals	Qualitative interview method
Managerial strategies	Structural, processual, and cognitive management	Both quantitative survey and qualitative interview methods
Collaborative team learning factors	Atmosphere, and challenges	Both quantitative survey and qualitative interview methods
	Trust, constructive conflict, and interdisciplinary collaboration	Qualitative interview method

Source: Developed by the author

To add, since the survey data allows testing the relationships between the variables, measured by the quantitative survey method, correlations by employing Pearson's r test in SPSS is hence to be tested between interdisciplinarity dimensions, professional factors, managerial strategies, atmosphere, and challenges, to name these. It should be noted though that considerable differences have been observed in the results between the same variables in the data sets from different meetings. As no common trends have emerged in the relationships from all seven survey data sets, the results are to be provided in Appendix only for a better orientation for the reader. They will not, however, serve as a decisive empirical proof in the analysis.

3.3. Methodological approach

3.3.1. Case study method

The present study is to follow a case study research design. A case study is seen as a study of social phenomenon, and is characterised by the criteria, introduced by Swanborn (2013). The author defined the case study as primarily focused on process, carried out within the boundaries of a social system, and guided by a broad research question that eventually develops into a concrete focus within the given case (Swanborn, 2013). Moreover, a case study is an intensive approach to the analysis, with a focus on variables and the ways the scores on pair (or sets) of variables change over time, rather than on collecting data on a large number of instances (Miskovic, 2011). As such, an in-depth longitudinal case study research design perfectly serves the research question of this study for exploring the Globaqua project in a thorough manner, and for

potentially providing a comprehensive explanation of the progress of scientific knowledge integration in the project by invoking an empirical evidence of factors and conditions of various types, influencing this progress.

Moreover, according to Marshall (1996), research method(s) is to be determined by the research question and design. For this reason, the present study is to employ the triangulation of methods in order to enable an in-depth exploration of an empirical puzzle of the Globaqua case. To note, triangulation requires that two or more methods are intentionally employed for analysing the same case, and are to be implemented independently, yet simultaneously (Greene & McClintock, 1985). In particular, Swanborn indicated that a case study has to be based on several data resources, following the exact order of document analysis, interviews, and observations (Miskovic, 2011). For this reason, a mix of quantitative and qualitative methods is to be employed in the present study: a quantitative survey and the qualitative interview. Also, the Description of Work (hereinafter – DoW) of Globaqua will be analysed with regard to certain aspects, such as the organisation of work between project partners, the channels that partners have for sound communication, and other. Lastly, instead of observation data, survey data will provide a large data set of monitoring the degree of scientific knowledge integration since the beginning of the project up to date.

It is essential to note that triangulation, as such, refers to the designed use of mixed-methods for offsetting or counteracting biases, inherent to particular methods, in investigation of the same phenomenon, as well as for strengthening the internal validity of inquiry results (Greene, Caracelli, and Graham, 1989). It also serves in enriching document analysis and quantitative data results with a new, or more precise information, obtained by qualitative interviews. Finally, triangulation helps explaining quantitative data results. Hence, in addition to the quantitative data and document analysis, qualitative interviews are to significantly contribute to answering 'why?' and 'how?' questions in explaining a complex interdisciplinarity progress in Globaqua (Marshall, 1996). Yet, although the application of mixed-methods is to enhance internal validity of this study, and to help overcoming intrinsic biases of single methods, external validity of this research remains limited.

3.3.2. Data collection

Survey

According to Masse et al. (2008), ideally, evaluative measures should be carried out and administered over the entire course of large IDR initiatives. Thereby, a progress of interdisciplinarity in Globaqua is intended to be measured based on the data, collected in three different types of structured survey questionnaires that have been developed and designed specifically to three types of official Globaqua project meetings:

- General Assemblies (for the General Assembly survey questionnaire, see Annex 1);
- Module meetings (for the Module meeting survey questionnaire, see Annex 2);
- Sampling campaigns (for the Sampling campaign survey questionnaire, see Annex 3).

The questionnaires were handed to the participants of these meetings, and were filled in anonymously. Yet, a unique coding system was developed to enable tracing each participant's (changed) perceptions over time.

The questionnaires were handed to the participants of these meetings, and were filled in anonymously. Yet, a unique coding system[2] was developed to enable tracing each participant's (changed) perceptions over time.

With regard to the questionnaire constructs, a series from 2 to 7 Likert-type items are combined into "Likert scales" in the questionnaires that stand for single composite variables, and have a quantitative measure of a particular trait to be used in the data analysis process (Boone & Boone, 2012). In relation to every construct, respondents were asked: *"Please indicate to what extent you agree with the following statements about…"* Five response options to the items anchor from 'strongly disagree', 'somewhat disagree' to 'somewhat agree' and 'strongly agree', with 'not sure' in the middle. To properly analyse Likert scale data, specific data analysis procedures of the descriptive statistics are recommended, such as mean (M) for central tendency, standard deviations (SD) for variability, also, Pearson's r test (Boone & Boone, 2012). The results of these tests will be provided in the empirical analysis.

For capturing an exact degree of interdisciplinarity, the value to the variable has to be assigned. As such, interdisciplinarity will be assessed on a 5-point scale, depicted in Figure 3 below, ranging from 1 to 5, accounting to 'low', 'relatively low', 'moderate', 'relatively high', and 'high respectively'. If a number is per comma, the score will be rounded to a higher half. Notably, unlike the other three interdisciplinarity dimensions, the scope of IDR will not be evaluated in scores as it does not capture interdisciplinarity content.

Figure 3. 5-point scale for capturing the degree of interdisciplinarity

Source: Developed by the author

Lastly, one of the main uncertainties in statistical analysis is the reliability of the measurement scales. In the present study, it has been determined a priori that the items of each construct likely measure a particular factor. Then, by using the SPSS 23.0, an internal consistency test of the scales has been employed in order to see whether the hypothesized factor structures can be verified as reliable. As a result, almost all constructs, with some minor modifications, were validated as reliable – around 0.7 or higher, and hence have been considered to be acceptable (Cortina, 1993). In total, 8 scales have been developed that will be further analysed in this research. Three of them capture a degree of interdisciplinarity – 'interactive research', 'integrative understanding', and 'effectiveness in advancing understanding', whilst the other five embody factors and conditions of various types – 'atmosphere', 'challenges', 'structural managerial tasks', 'processual managerial tasks', and 'cognitive managerial tasks'. A detailed summary of the reliability coefficient (Cronbach's Alpha) of each construct is discussed and summarised in Table 13 in sub-section 5.4.2.

[2] The unique code consists of the first letters of the respondent's mother and father's names, as well as of the last two digits of the respondent's birth year, for instance, AL78.

Interviews

For collecting the qualitative data, a semi-structured interview method has been applied. The questionnaire has been developed based on the theoretical framework of this study. The structure of the questionnaire is composed of five main parts, each of which addresses the composite elements of the conceptual model, and in total, it contains 23 questions. Also, during the semi-structured interview, the respondents have been asked additional questions for clarifying their answers, as well as some leading questions for a better understanding of what they say.

Having carried out all 10 interviews with Globaqua participants, the data has been processed partly by coding the answers to certain questions, and partly by summarising the core concepts and themes that emerged during most of the interviews, such as different dimensions of interdisciplinarity, other composite elements of scientific knowledge integration progress, also, a range of factors and conditions, influencing interdisciplinary collaboration in Globaqua, to name a few.

As well as in the case of the quantitative data analysis, the scores are to be assigned, when assessing the degree, to which each of interdisciplinarity dimensions has been achieved so far in the project. For this purpose, the same 5-point scale is to be invoked (see Figure 3 above). The degree of each dimension will be decided based on the overall observation of the researcher of this study, counting on the qualitative interviews data. As the dimensions have their characteristic items, logically, the highest score – 5 points is to be assigned to the dimension, when all of its composite items are evidently achieved (and/or developed) in Globaqua, and conversely – a dimension will be evaluated to the lowest score of 1 point, if no (or a very small portion of) composite items are found to be present in the analysed case. Further, what concerns the 'moderate' degree of 3 points, it is to be assigned, if indicatively half of the composite elements of a given dimension are found, based on the interviews data. Then, a 'relatively low' degree, accounting to 2 points, is to be grounded in the empirical finding that less than half, but more than none or a very small portion of the constituting items are found to be achieved and developed in the Globaqua case. In contrast, if more than half, but less than all constituting items of particular dimensions can be stated as profoundly reached in the project, the score to be assigned to a given dimension is 4 points, amounting to a 'relatively high' degree.

3.3.3. Participants

Globaqua survey respondents

As the overall aim of all quantitative sampling approaches is to draw a representative sample from the population in order to generalise the results back to the whole population (Marshall, 1996), it has been decided prior to starting this research to hand in the surveys to all the participants of three different types of Globaqua meetings. For this reason, indicating the overall size of the survey sample is complicated due to a considerable variation in the participation rates of the project partners in both General Assemblies, three Module meetings, and both Sampling campaigns. As such, the size of the seven samples range from 13 to 45 respondents (see Table 6 below).

Table 6. List of the Globaqua survey samples of different project meetings

Meetings	Questionnaires	Sample size
General Assembly in Athens, Greece (2014 November)	General Assembly questionnaire	**42**
General Assembly in Munich, Germany (2016 January)	General Assembly questionnaire	**45**
Sampling campaign in Adige river basin (2015 July)	Sampling campaign questionnaire	**16**
Sampling campaign in Sava river basin (2015 September)	Sampling campaign questionnaire	**13**
Module meeting in Barcelona, Spain (2015 May)	Module meeting questionnaire	**18**
Module meeting in Tubingen, Germany (2015 November)	Module meeting questionnaire	**27**
Module meeting in Barcelona, Spain (2016 April)	Module meeting questionnaire	**27**

Source: Developed by the author, based on the statistical survey data analysis

To add, participation of the Globaqua partners in all meetings by the unique respondent codes is tabled in Appendix 1, whilst the descriptive statistics of all the survey respondents in terms of *gender*, *disciplinary background*, and *years of experience in IDR* variables are precisely summarised in Appendix 2.

Globaqua interviews respondents

When speaking about the interviews sample, it is important to elaborate on the selection process, as well as on the size of the sample. With regard to the first, a careful selection of 10 interviewees has been based on one of the most common sampling strategies, called 'judgement' or 'purposeful' sample (Marshall, 1996). As the Globaqua project structure is built on five thematic blocks – Modules, and fourteen work packages that fall under these Modules in terms of specific tasks to be carried out in the project, the choice to interview all Module leaders, and a large portion of work package leaders has been made based on certain criteria. First, both Module and work package leaders are the scientists, working mainly on the interfaces between various academic disciplines, and connecting the people, representing the different disciplinary fields. Second, as the variability of participation in the Globaqua activities is high, both Module and work package leaders are the first points of contact, as well as the people that are expected to actively participate in a majority of the official project activities and meetings. Third, as a specific focus has been put in this study on the way and the overall Globaqua project work is organised and managed, both Module and work package leaders are the ones, actually undertaking the role of coordinating and planning the work of and between the Modules and the work packages. Fourth, it should be noted that as a result of a purposeful selection of the sample, all ten interview respondents represent ten different contractual partners of the Globaqua Consortium. This fact suggests a relatively wide range of different experience and expertise in the field of IDR to be shared by the respondents. Finally, the careful selection of the interviewees among the 14 work package leaders involves two leaders per each Module, which suggests that, in the case of the smaller Modules, such as Module 2, 4, and 5, all work package leaders have been interviewed. Altogether, interviews sample is considered to be sufficiently representative. Also, the selected sample is seen as a rich source of important and relevant information and knowledge to be shared during the interviews.

With regard to the size of the sample, it has been determined by two criteria. First, as an appropriate sample size for a qualitative study is considered to be the one that adequately answers the research question

(Marshall, 1996), the sample of the interviewees in this study has been sufficient in terms of answering not only the main research question, but also the research sub-questions in a conclusive manner. Second, it is usually the case that the size of the sample becomes obvious only in practice, when the study is in progress, and no new questions, themes, or explanations are emerging from the data (Ibid). Due to this exact situation, referred to as "data maturation", no additional interviews have been deemed as necessary in addition to the initially selected sample for this study.

Taking all into consideration, 10 out of 14 (71%) Globaqua work package leaders have been interviewed. The sample includes all five Module leaders as well, making the sample representative. Table 7 below presents the list of the respondents of the semi-structured interviews, carried out in 2016 June via Skype calls, or over a phone. For clarification of the respondents' institutions in abbreviations, see Appendix 3.

Table 7. List of the Globaqua interviews respondents

Modules	Module leaders	Work package	Work package leader
Module 1 – STRESSORS	Ralf Ludwig (LMU)	**WP-1**	-
		WP-2	Ralf Ludwig (LMU)
		WP-3	Alberto Bellin (UNITN)
		WP-4	-
		WP-5	-
Module 2 – RECEPTORS	Isabel Muñoz (UB)	**WP-6**	Isabel Muñoz (UB)
		WP-7	Arturo Elosegi (UPV/EHU)
Module 3 – IMPLICATIONS	Phoebe Kondouri (ANTHENA)	**WP-8**	Vicenç Acuña (ICRA)
		WP-9	Phoebe Kondouri (ATHENA)
		WP-10	-
Module 4 – ENVIRONMENTAL MANAGEMENT	Nick Voulvoulis (IMPERIAL)	**WP-11**	Alberto Pistocchi (JRC-IES)
		WP-12	Nick Voulvoulis (IMPERIAL)
Module 5 – PROJECT COORDINATION AND DISSEMINATION	Damià Barceló (CSIC)	**WP-13**	Gabriele Sacchettini (AEIFORIA)
		WP-14	Damià Barceló (CSIC)

Source: Developed by the author, based on Barcelo (2013)

Chapter IV: Globaqua case introduction

The fourth chapter is going to thoroughly introduce the case study – the Globaqua project, to be analysed in the empirical part. First, the context that the project is focused on is to introduced, coupled with a presentation of the Globaqua Consortium and the main project objectives. Next, the overall project work is organised will be briefly discussed in terms of the management structure, and the collaborative work plan that the project partners have to implement. Lastly, the project timeline is to be presented, identifying three different types of official Globaqua meetings, during which interdisciplinarity progress is to be measured in the empirical part of this study.

4.1. The area of focus: river basin management

As most freshwater systems in Europe are currently threatened by a variety of stressors, Globaqua specializes on addressing a specific set of stressors to illustrate different management scenarios. In particular, it assesses the effects of water scarcity on aquatic ecosystems by focusing on six river basins: Ebro, Adige, Sava, Evrotas, Anglian, and Souss Massa, of a wide geographic coverage. Within this context, Globaqua aims at achieving a better understanding of how current management practices and policies could be improved by identifying their main drawbacks and alternatives (Barcelo, 2013). To do so, a cross-scale approach of data-mining, field- and laboratory-based, and modelling at different spatial scales and socioeconomic research is being applied.

To answer the questions that have been put forward in Globaqua, a multidisciplinary team of leading scientists in a range of disciplines has been assembled. Disciplinary diversity covers chemistry, biology, ecology, geomorphology, hydrology, economics and sociology, including hydrological, biophysical and ecological modelling, also, socio-economics and governance science, knowledge brokerage and policy advocacy. As such, Globaqua is composed of 22 European partners from 10 countries: France, Germany, Greece, Italy, the Netherlands, Slovenia, Spain, Sweden, Croatia, and the United Kingdom, including 1 associated country – Serbia, and 2 non-EU partners – Morocco and Canada. In total, a multidisciplinary Consortium comprises 25 principal contractors (see Appendix 3). A complex selection process of the partners was done mainly on the basis of a depth of their previous experience, as well as of their long-term strategic interest in the project topics. The project has received funding from the European Union's 7th Framework Programme (FP7) for Research, Technological Development, and Demonstration, and has commenced in 2014 February. Globaqua Consortium strives for achieving two major complementary objectives:

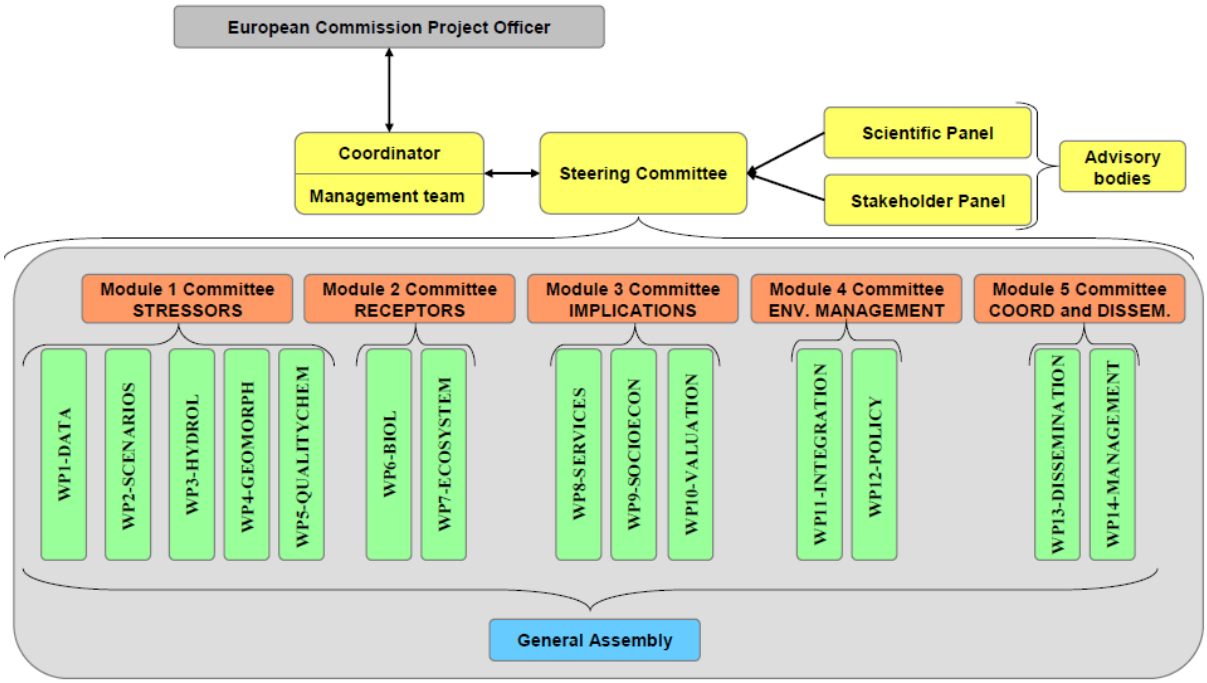
1) To deal with fundamental research questions in relation to an improvement of knowledge on relationships between multiple stressors;
2) To address the urgent need to improve water management practice and policies by taking into consideration the influence of multiple stressors in relation to the European Union Water Framework Directive (2000/60/EC) and other related regulations (Barcelo, 2013).

4.2. Project organisation

4.2.1. Management structure

Organisation and coordination mechanisms, based upon highly successful experiences of former EU projects, have been established in Globaqua, and are being executed according to the international management standards. Given, a range of administrative, financial, scientific, and knowledge and innovation tasks fall under the Globaqua management. To ensure they are fulfilled, the management structure is based on a transparent vertical and horizontal cooperation among various interrelated bodies, and their leaders. The detailed scheme of Globaqua management structure is illustrated in Figure 4.

Figure 4. Globaqua management structure



Source: Barcelo (2013: 75)

The focal point is the Steering Committee that serves as the project executive board, responsible not only for administrative and financial decisions, but also for the overall project strategy. Led by the Project Coordinator Damià Barceló, the Committee represents the highest level of decision-making within the project, and is supported by two advisory panels – Stakeholder and Scientific, as well as by the Management Team. Namely, the latter ensures the overall day-to-day coordination of all Consortium-related issues, and scientific research coordination. As depicted in Figure 4, Globaqua is arranged in five Modules, comprising fourteen work packages, and both Modules and work packages are led by the assigned leaders.

4.2.2. Collaborative work plan

The project organisation is implemented through collaboration of 14 WPs, which fall under five Modules. The latter address five integrative themes to be thoroughly investigated in order to achieve Globaqua objectives. To facilitate the implementation of the project, and to enhance scientific knowledge integration among different disciplines, a particular collaborative scheme was set to be followed, provided later in Chapter 5, when analysing interaction pathways in the project. Yet, detailed description of the interrelation between the Modules and work packages in terms of their tasks and project work is provided in Appendix 4.

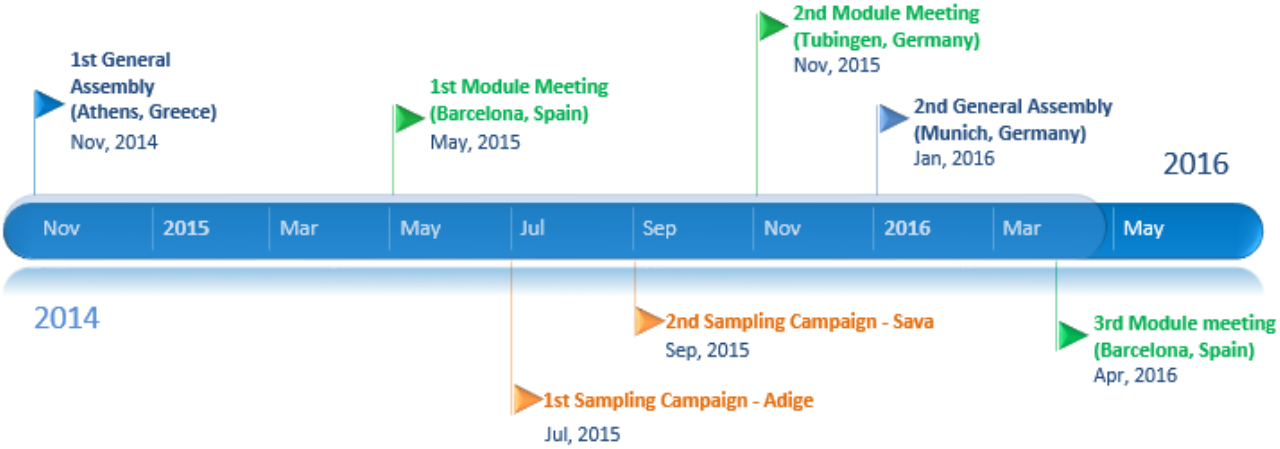
Along with the collaborative work plan, a number of significant risks have been identified by the project management in the project proposal, ranging from low to high probability with either low, medium, or high impact on the project. Accordingly, contingency plans to overcome these risks have been developed in order to ensure an uninterrupted implementation process of the project. Most of the risks are task-specific and relate to the content, meanwhile, some of them indicate a more general, but highly essential challenges, for instance, that Globaqua is likely to be exposed to the risk of ensuring effective data exchange and cooperation within among the partners. For this reason, the structure of Globaqua project is "an example of integration between WPs and basin case studies", and it "offers a strong interdisciplinary team" (Barcelo, 2013: 71; 16). Such organizational setting is hence expected to facilitate the knowledge transfer between the WPs within and among the modules. To add, "frequent meetings and collaborative deliverables have been proposed to address this major challenge" (Ibid: 71). Building upon this aspect further, next section will introduce the project timeline in terms of the official Globaqua meetings.

4.3. Globaqua in process: official project meetings

Being a large scale interdisciplinary project, Globaqua has been designed to have three different types of official project meetings in relation to the tasks and the objectives to be achieved in the project. In fact, all three types of meetings fundamentally differ in their core idea, objectives, and organisation and participation. First, Globaqua General Assembly oversees all activities, related to publishing and exploiting project results, and takes place roughly once a year. It assembles all project partners, and enables exchanging and sharing the core project ideas, plans, as well as the project issues that necessitate more attention. Second, Globaqua Module meetings of a much smaller scale, and are designed to review and proceed with subject-matter questions and tasks that fall under the responsibility of certain Modules. The meetings are mainly meant to improve internal Modules' progress, but can also serve for the inter-Modular purposes. Third, Globaqua Sampling campaigns are fieldwork activities, specifically organised in relation to one of the six project case studies – different river basins in Europe. For this reason, no overlaps in participation in different Sampling campaigns between the project partners is to take place as each of them work only on one case study in the project. Sampling campaigns are essential for collecting the necessary data and samples from the field in order to model the different scenarios, as aimed in the Description of Work of Globaqua.

As of 2016 June, seven official Globaqua meetings have taken place – two General Assemblies, three Module Meetings, and two Sampling Campaigns. All meetings are depicted in the project timeline in Figure 5 below.

Figure 5. Project timeline of the official Globaqua meetings since 2014 February until 2016 April



Source: Developed by the author

Notably, although the kick-off meeting of Globaqua took place in 2014 February, the first attempt to evaluate scientific knowledge integration in the project via survey was made in the first General Assembly in Athens (Greece) in 2014 November. The first Module meeting followed next in 2015 May in Barcelona (Spain). Then, two Sampling campaigns were organised in turn – in 2015 July and September, in relation to two project case studies – Adige and Sava river basins respectively. Next month, the second Module meeting took place in Tubingen (Germany). In the beginning of 2016 in January, the second General Assembly was organised, and attracted the highest number of participants thus far. The last – third Module meeting has taken place recently in 2016 April. Notably, this meeting was organised for discussing the data collected in the Sampling campaigns, and projecting further work for producing the desired results. In this sense, this meeting significantly differs from the other two Module meetings, and can also be called 'Sampling meeting'.

Chapter V: Investigating the degree of interdisciplinarity in Globaqua

This chapter will turn into the empirical part of this research, and will start of by investigating the dependent variable – scientific knowledge integration in Globaqua. Hence, the first research sub-question is to be answered conclusively in this chapter:

- How the degree of interdisciplinarity in Globaqua is perceived by the participants?

First, three dominant ways to define interdisciplinarity in Globaqua will be introduced for an illustration of the different perceptions of interdisciplinarity, prevailing among project partners. Then, the results on the degree of interdisciplinarity will be extensively discussed in terms of its composite dimensions. The latter task is to be done based on both – quantitative and qualitative data sets, for the purpose of comparing the results, as well as of drawing some generalising findings with regard to the dependent variable at the end of this chapter. As such, the last section will present a summary of the results from both quantitative and qualitative analyses.

5.1. Interdisciplinarity: one concept - different perceptions

Prior to capturing the degree of scientific knowledge integration in Globaqua, it is useful to discuss how the concept of interdisciplinarity is perceived by the scientists, involved in the project. In fact, not only it is interesting, but also important as one's perception of interdisciplinarity eventually determines his/her approach, when speaking about knowledge integration and its progress in the project. Yet, as the aim of this study is not to measure the perception of people, but rather the progress of interdisciplinarity, henceforth, only a brief summary of three dominant ways in Globaqua to define interdisciplinarity is further presented.

The first approach relates to a physical composition of a group in a project, meaning that a (large) number of disciplines from various fields are involved in achieving project goals. The idea is that when disciplines from often disparate fields, for instance, Natural and Social Sciences are participating in the project, it is a precondition for having a truly interdisciplinary design of the project, which is likely to result in scientific knowledge integration between the scientists from these disciplines. When speaking about one of the previous projects, one interviewee shared an insight:

> *"This project involved people from engineering, biology, chemistry, toxicology, so, it was highly interdisciplinary".*

From the first sight, it may seem that interdisciplinarity may (un)consciously being mixed up with the concept 'multidisciplinarity'. Nevertheless, most of the time, in the cases, where biologists, toxicologists and engineers are up for working together, they have a potential for doing a truly interdisciplinary research. Thus, one of the ways to approach interdisciplinarity is from the perspective of a composition of a group in terms of disciplinary diversity, and the opportunities it has for interdisciplinary collaboration.

The second way to define interdisciplinarity, prevalent in the project, is to look at the problem that it is set to be addressed. The importance of having a wicked issue to solve was emphasized by the respondents:

> *"My perspective is that in order to have a real interdisciplinary project or an interdisciplinary approach, the only way to do it is to, first, have a problem to investigate – a question that really requires an interdisciplinary approach".*

In this respect, this way of defining interdisciplinarity is novel, and neither discussed in this study, nor discovered in the literature on interdisciplinary research. Regardless, it indeed suggests a fruitful insight for designing future large scale projects, in which a high degree of IDR is desired. Moreover, this approach could complement the first dimension of interdisciplinarity – scope of IDR – in future research, when capturing the degree of interdisciplinarity in any project as it nicely depicts the scale to which interdisciplinarity is expected to be reached. The interview results show that a large proportion of the respondents attribute the highest importance to this way of approaching interdisciplinarity, as then it is ensured that the project requires disciplinary inputs from scientists in order to address a complex problem at stake at the end. To illustrate:

> *"Interdisciplinarity is when different disciplines allow having a new version of reality. The one and absolute value of all this is that you can have contributions from all of these lenses, and that gives you a much more complete version of the picture".*

The third and the most common perception of interdisciplinarity in Globaqua directly conforms to the way it is defined in this study as interdisciplinary collaboration. The findings hence are pleasing as the dominant portion of the project participants perceive scientific knowledge integration as a process, during which the fundamentals of interdisciplinary collaboration truly materialize. One of the partners put it in his words as:

> *"I see interdisciplinarity very much as a mode of working that comes with reflections in the course of action. Also, as a process of how we talk to and interact with each other".*

In addition, not only talking to each other, but also aligning the direction of disciplinary work, as well as exchanging ideas, setting up models together, mixing different types of data for comparing and merging it, and similar activities fall under this way of defining interdisciplinarity. In other words, not only it is essential to express one's expectations and needs for having a uniform direction of work, but also for creating a shared understanding of the problem. That is to say:

> *"People from different disciplines can exchange ideas, knowledge, and work together. In this way they generate new knowledge".*

The last, but of an equal importance, is the aspect, mentioned by a significant majority of the respondents – to truly have a common goal to achieve together, which requires inartificial interaction between disciplines of a different nature. To illustrate:

> *"Interdisciplinarity would be to put people from different disciplines to work together in order to achieve a common goal. They cannot achieve a common goal, unless they work together".*

So, to sum up the findings on how to Globaqua partners define interdisciplinarity, it can be justified that the most common approach to interdisciplinarity conforms to the definition, used in this study:

> *"The objective is not to reach interdisciplinarity – it is rather a means to an end, but not the end. I see interdisciplinarity as a tool to do research".*

The summary of all three ways of defining interdisciplinary in Globaqua is provided in Table 8 below.

Table 8. Three dominant perceptions of interdisciplinarity in Globaqua

Perceptions of interdisciplinarity	Explanation
1. A composition of a group in a project	A physical composition of a group of the project in terms of disciplinary diversity is a pre-condition for interdisciplinarity.
2. A complex problem to be addressed	Having a complex problem that requires truly interdisciplinary approach serves as a precondition for enhancing interdisciplinary research between project partners.
3. A mode of doing research	A process of people from different disciplines working together on a common goal by, for example, exchanging ideas, setting up models, mixing data of different types, and trying to compare and merge the results. In this respect, a common goal should be explicit, and it is to be achieved only, if truly working together.

Source: Developed by the author, based on the qualitative interviews data analysis

Altogether, these and several other single perceptions, different to the definition of interdisciplinarity in this research, imply that interdisciplinarity by the Globaqua partners is understood not in a uniform way. Instead, this finding suggests that further interdisciplinarity evaluations, made by both survey and interview respondents, are simply affected by one's understanding of what interdisciplinarity truly is.

5.2. Evaluating interdisciplinarity in Globaqua meetings: quantitative analysis

The first step in measuring the degree of scientific knowledge integration in Globaqua is to be made in a quantitative manner. An extensive discussion on interdisciplinarity dimensions in turn will unfold in accordance to the project timeline. In sum, the surveys were filled in by the respondents in seven meetings – two General Assemblies, two Sampling campaigns, and three Module meetings by evaluating four dimensions – *the scope of interdisciplinary research, interactive research, integrative understanding,* and *effectiveness in advancing understanding.* With this in mind, the mean scores on each of the dimensions will be reviewed between the different types of meetings, and compared between the same types of meetings, structuring the section in accordance from the first to the fourth dimension. Notably, as the scope of interdisciplinarity does not contain knowledge integration, the assessment of it is to be made not by assigning the score, but by assessing the scope of disciplinary diversity in the project. It is also important to note that comparisons of the scores on the dimensions bear explanatory power only in the cases of General Assemblies and Module meetings, excluding Sampling campaigns. This is because the idea behind organising the Sampling campaigns is in relation to a specific case study of Globaqua, so, the participation of scientists does not overlap, making the comparisons of the scores between the Sampling campaigns not reasonable.

5.2.1. The scope of interdisciplinary research

Two General Assemblies – 2014 November and 2016 January

In the first General Assembly in Athens (Greece) in November 2014, first attempts to assess interdisciplinarity in Globaqua were made. The first dimension – the scope of IDR – contains five different academic disciplines as a result of 42 participants: Physical Sciences, Life Sciences, Environmental Sciences, Engineering, and Social Sciences, represented by 11, 4, 14, 5 and 5 scientists respectively.

In the second General Assembly in Munich (Germany) in 2016 January, 45 anonymous questionnaires were completed. The same five academic disciplines were present in the meeting as in the first General Assembly, represented by 17, 5, 13, 3, and 4 scientists accordingly.

Two Sampling campaigns – 2015 July and September

The first Sampling campaign took place in relation to the case study of Adige river basin in 2015 July. A group of 16 scientists represented four disciplines: Physical Sciences, Life Sciences, Environmental Sciences, and Engineering, with a respective number of 4, 3, 4, and 2 researchers.

The data from the second Sampling campaign in the Sava river basin in 2015 September indicates a narrower scope of IDR. 13 participants represented only three academic disciplines in the meeting: Physical Sciences, Life Sciences, and Environmental Sciences by 2, 5, and 5 scientists accordingly.

Three Module meetings – 2015 May, 2015 November, and 2016 April

In the first Module meeting in Barcelona (Spain) in 2015 May, 18 completed survey questionnaires depict a similar case as in the General Assemblies with regard to the scope of IDR in the meeting. The same five academic disciplines were present, with a dominant group of environmental scientists.

The data from the questionnaires, completed in the second Module meeting in Tubingen (Germany) in 2015 November, indicates fairly similar results, if compared to the first Module meeting. The scope of IDR amounts to the same five academic disciplines, although a significant majority of the 11 respondents in the meeting was from Physical Sciences.

Third, it should be noted that the third Module meeting in Barcelona (Spain) in 2016 April slightly differed from the other two meetings in its objective and participation. It was organised for discussing data and results, collected and produced as a result of both Sampling campaigns. Although the focus in the meeting was put on the progress made in the project in terms of the case studies, it was organised and managed in the same fashion as a Module meeting, and hence is considered to be a third Module meeting. Now, with regard to the scope of IDR – it amounted to four academic disciplines, represented by the respective number of scientists: Physical Sciences (11), Life Sciences (8), Environmental Sciences (7), and Social Sciences (1).

Overall statistics of the first interdisciplinarity dimension in Globaqua meetings is provided in Table 9 below.

Table 9. Overall statistics of the scope of interdisciplinary research in Globaqua meetings

Meetings	The scope of interdisciplinary research							
	Sample (N)	Number of disciplines present	Types of disciplines involved					
			Physical Sciences	Life Sciences	Environmental Sciences	Engineering	Social Sciences	Mixed
General Assembly (2014 November)	**42** (100%)	5	11 (26%)	4 (10%)	14 (33%)	5 (12%)	5 (12%)	3 (7%)
General Assembly (2016 January)	**45** (100%)	5	17 (37%)	5 (11%)	13 (29%)	3 (7%)	4 (9%)	3 (7%)
Sampling campaign (2015 July)	**16** (100%)	4	4 (25%)	3 (18.5%)	4 (25%)	3 (18.5%)	-	2 (13%)
Sampling campaign (2015 September)	**13** (100%)	3	2 (15%)	5 (38.5%)	5 (38.5%)	-	-	1 (8%)
Module meeting (2015 May)	**18** (100%)	5	4 (22%)	3 (17%)	7 (39%)	2 (11%)	1 (5.5%)	1 (5.5%)
Module meeting (2015 November)	**27** (100%)	5	11 (41%)	4 (15%)	7 (26%)	1 (4%)	2 (7%)	2 (7%)
Module meeting (2016 April)	**27** (100%)	4	11 (41%)	8 (29%)	7 (26%)	-	1 (4%)	-

– = not participated in a meeting

Source: Developed by the author, based on the statistical survey data analysis

Evidently, the scope of IDR in both General Assemblies and in the first two Module meetings is the broadest – 5 different disciplines were involved, if compared to the Sampling campaigns and the third Module meeting. In contrast, a relatively narrow scope of IDR is observed in the Sampling campaigns due to the reason that the participation in these meetings is case-study-specific, and, thus, involved no social scientists. With an exception of the last Module meeting, the two most dominant groups in all meetings were represented by the Natural scientists and the Environmental scientists. Meanwhile, Social scientists account only to a small portion of the participants in all seven meetings (up to 12% of the sample at most).

5.2.2. Interactive research

Data on the second dimension – *interactive research* shows certain differences in the overall scores between the different types of meetings. In the case of the General Assemblies, in the first meeting, interactive research was evaluated to 3.7 points on average by the respondents. The score marginally increased up to 4 points on average in the second General Assembly. Both scores account to a 'relatively high' degree of

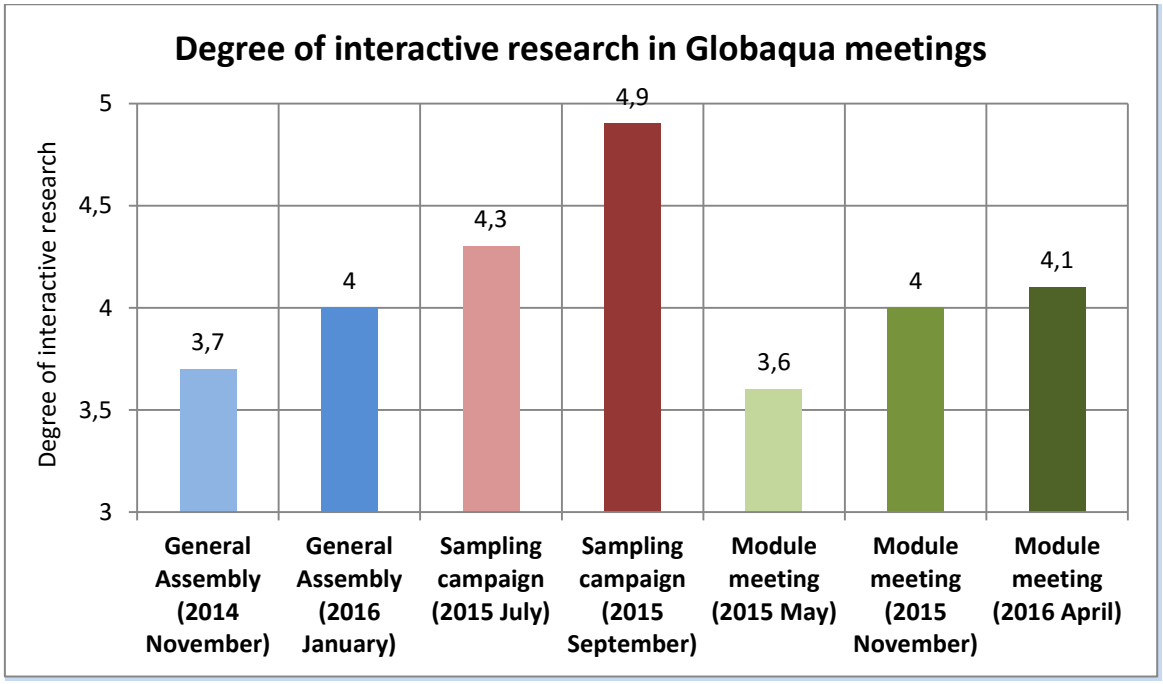
interactive research, which is to some extent surprising, having in mind that such degree was already present in the beginning of the project.

Speaking about the degree of interactive research in the Sampling campaigns, the results differ considerably from the above case. Interactive research was evaluated by the respondents for 4.3 points on average in the first Sampling campaign. The score in the second Sampling campaign amounted to 4.9 points on average, nearly indicating the highest possible score degree. Notably, although that the construct in the data from the second meeting shows an error, thus, the results should be taken into account with reserve (for more, see section 5.4.2).

Third, the data from Module meetings shows a similar expression to the General Assemblies. A steady growth is observed in all three Module meetings. In the first, interactive research degree reached 3.6 points on average, whilst in the second meeting, it increased up to 4 points on average. A marginal growth in the score is seen in the third meeting, accounting to 4.1 points on average. Overall, all three meetings indicate the dimension being advanced to a 'relatively high' degree.

The scores on interactive research from all seven meetings is depicted in parallel in Figure 6 below.

Figure 6. Degree of interactive research in Globaqua meetings



Source: Developed by the author, based on the statistical survey data analysis

5.2.3. Integrative understanding

Results with regard to the third interdisciplinarity dimension – *integrative understanding* demonstrate highly similar expression to the case of the second dimension. In the first General Assembly, the respondents assessed integrative understanding being achieved to a 'relatively high' degree of 3.6 points on average,

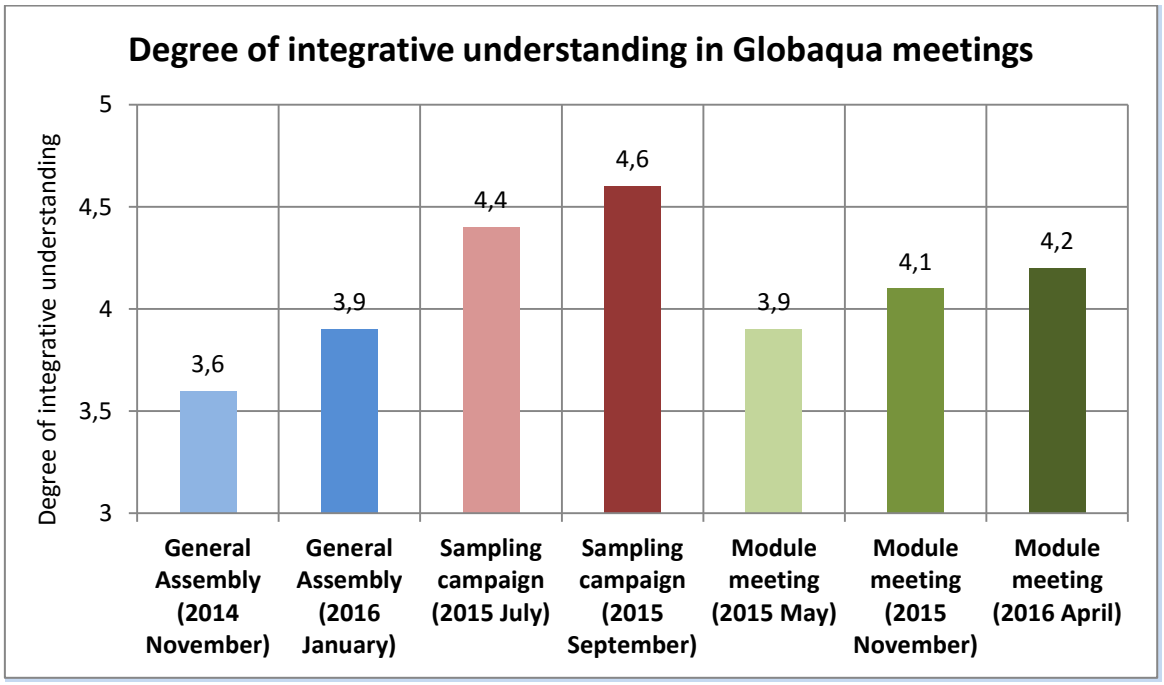
which remained the same in the second General Assembly as well, only indicating a gradual increase in the average score – 3.9 points. The assessment of this dimension in both General Assemblies is nearly identical to the degree of interactive research.

Looking at the data from the Sampling campaigns, again, evident differences are present. Integrative understanding was evaluated as 'relatively high' (4.4 points on average) in the first Sampling campaign, whilst in the second meeting two months later, the degree accounted to 4.6 points on average, being 'high'.

Finally, the results from all three Module meetings suggest almost identical expression as in the case of interactive research dimension as well. A steady growth in the scores is observed in the first, the second, and the third meeting, accounting to a 'relatively high' degree of integrative understanding being achieved up to 3.9, 4.1, and 4.2 points on average.

The results from all seven Globaqua meetings are depicted in parallel in Figure 7 below.

Figure 7. Degree of integrative understanding in Globaqua meetings



Source: Developed by the author, based on the statistical survey data analysis

5.2.4. Effectiveness in advancing understanding

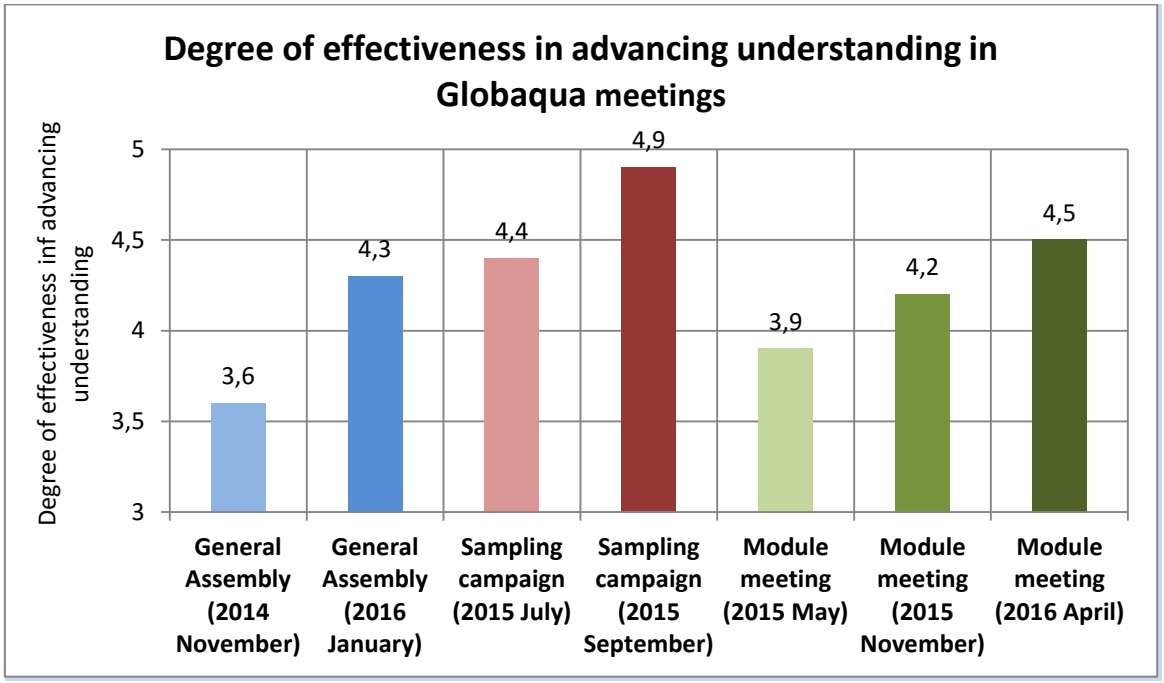
Lastly, the fourth interdisciplinarity dimension – *effectiveness in advancing understanding* needs brief elaboration in terms of scoring in Globaqua meetings. As for the first General Assembly, the mean score of 3.6 points on this dimension is almost identical to the scores on the other two dimensions in this meeting. To add, the score in the second General Assembly soared up to 4.3 points on average, however, indicating the same 'relatively high' degree of effectiveness in advancing understanding in both General Assemblies.

In both Sapling campaigns, with no wonder, both mean scores are higher, compared to the scores from the other two types of meetings. In the first Sampling campaign, the respondents assigned a 'relatively high' degree of 4.4 points on average achieved in the meeting. Meantime, the second Sampling campaign again shows the highest score ever assigned in Globaqua meetings– a 'high' degree of 4.9 points on average.

Third, the results from all three Module meetings indicate a steady growth of the degree of effectiveness in advancing understanding of Globaqua. The mean score in the first Module meeting demonstrates a 'relatively high' degree of 3.9 points, as well as in the second Module meeting of 4.2 points on average. The third Module meeting was evaluated to a 'high degree', and was assigned 4.6 points on average.

The scores on effectiveness in advancing understanding from all meetings in turn are depicted in Figure 8.

Figure 8. Degree of effectiveness in advancing understanding in Globaqua meetings



Source: Developed by the author, based on the statistical survey data analysis

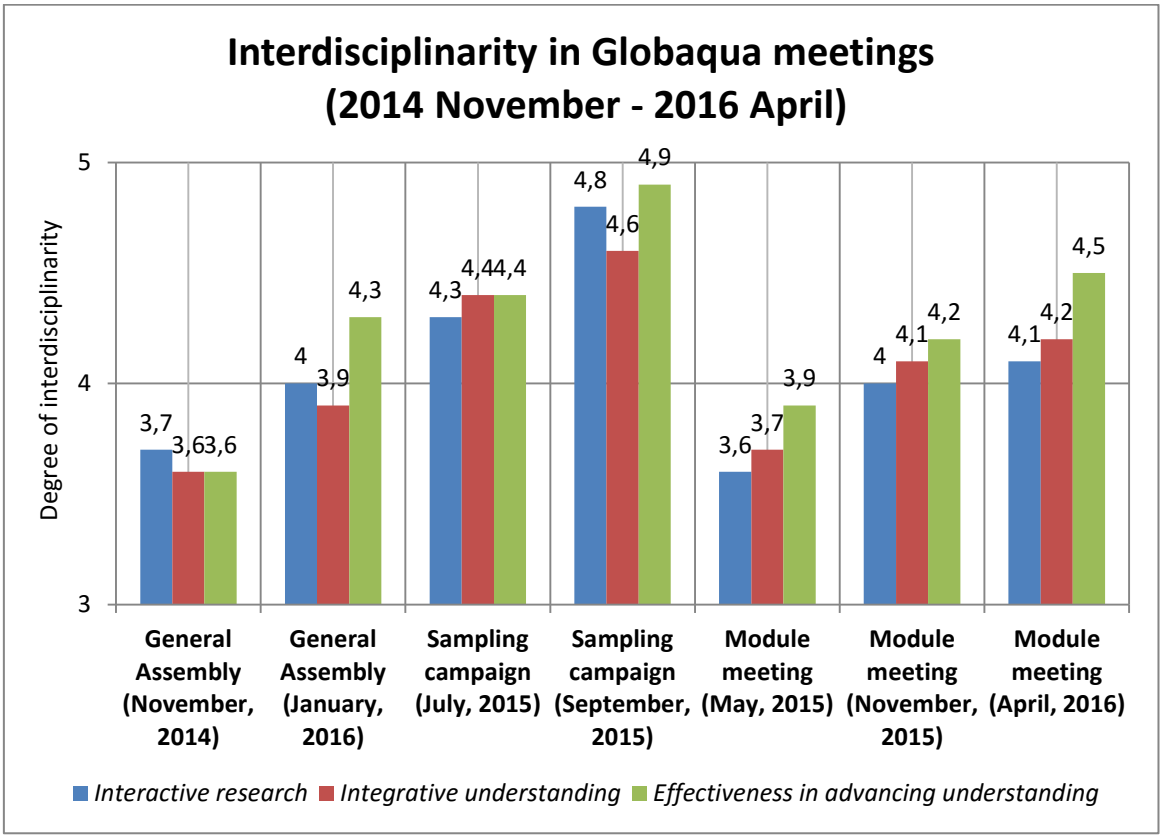
5.2.5. Overall interdisciplinarity in Globaqua meetings

Having thoroughly reviewed the mean scores on each dimension in all seven meetings, a closer look at the picture of the overall scores on interdisciplinarity up to 2016 April can be taken in Figure 9, depicting the scores on all dimensions in all meetings in turn.

Speaking about the overall scientific knowledge integration in General Assemblies, the data from the second meeting indicates more diverse scores on all three dimensions. That did not, however, affect the degree of interdisciplinarity: all dimensions were evaluated as 'relatively high'. Further, the assessments made by the respondents in both Sampling campaigns can be interpreted in a similar way: more variation in scores is observed in the second meeting. To note, the overall degree of interdisciplinarity reached a 'high' degree for

the first time in Globaqua as of 2015 September. With regard to the results on interdisciplinarity in the Module meetings, in contrast, all dimensions score steadily higher in all three meetings. As such, Figure 9 nicely depicts the finding that the effectiveness in advancing understanding dimension was rated the highest, compared to the other two dimensions in Module meetings. This finding suggests that, according to the survey respondents, Module meetings are contributing to advancing one's understanding (in terms of its constituent items) in the project the most out of all three dimensions in Globaqua.

Figure 9. Interdisciplinarity in the official Globaqua meetings from 2014 November to 2016 April



Source: Developed by the author, based on the statistical survey data analysis

Moreover, Figure 9 indicates that the survey respondents rate interdisciplinarity highest in the Sampling campaigns. In contrast, although both General Assemblies and Module meetings score lower, they amount to a fairly similarly scores in between.

Lastly, it should be noted once again that there is no relevance to look at the evolution of interdisciplinarity across all Globaqua meetings due to the differences in their organisation, objectives participation. Yet, if taking a glance at the changes in the degree of interdisciplinarity between the same types of meetings, a profound insight can be drawn: it is evident that the progress of the three scientific knowledge integration dimensions is observed in all Globaqua meetings. This evolutionary aspect of interdisciplinarity is hence discovered, based on the survey respondents evaluation, and implies that the framework, applied to measuring interdisciplinarity progress successfully facilitates the main research ambition.

5.3. Evaluating interdisciplinarity in the project: qualitative analysis

Like in the previous section, the structure of this part – a qualitative data analysis of the dependent variable will unfold in the same fashion. The overall assessment is to be made on the four composite dimensions in turn, in terms of their characteristic items, developed in the theoretical framework earlier in this study. Also, having systemically analysed the data, each dimension of interdisciplinarity will be evaluated on a five-point scale, introduced in the methodology (see section 3.3.2.). The results of this qualitative analysis are expected to enrich the findings of the statistical analysis, presented in the previous section, by revealing substantial explanatory socio-cognitive processes and properties of what it is referred to in this research as 'interdisciplinary collaboration'.

5.3.1. The scope of interdisciplinary research

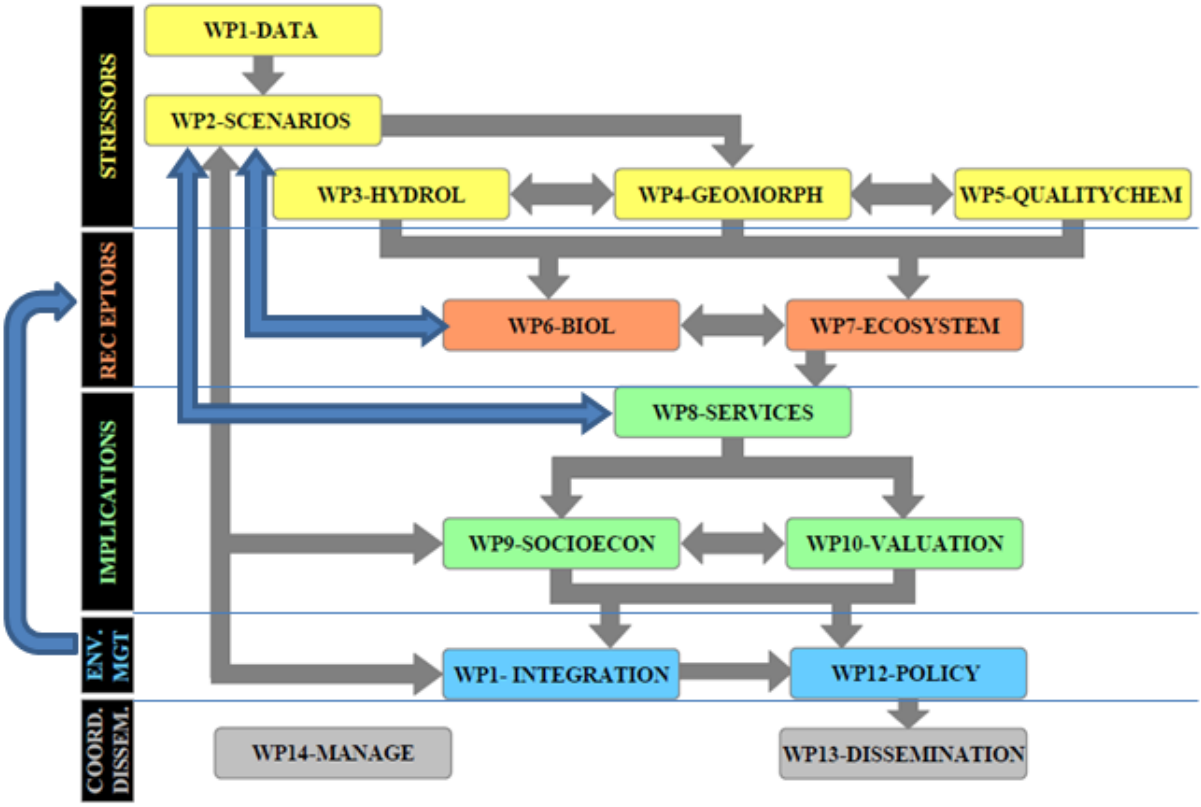
Assessment of the first interdisciplinarity dimension – the scope of IDR – is a straightforward task. Globaqua partners come from both sides of the interface between Natural and Social Sciences. According to the Description of Work (DoW), Globaqua aims at integration of different disciplines from various biophysical to socio-economic Sciences (Barcelo, 2013). As a result, multidisciplinary Globaqua Consortium comprises leading scientists in the fields of hydrology, chemistry, ecology, ecotoxicology, economy, sociology, engineering, modelling, and other. Although the debate on how certain disciplines should be classified is relatively complex in this case, all of them indicatively fall under 6 branches of academic knowledge – Physical Sciences, Life Sciences, Environmental Sciences, Engineering, Social Sciences, and Humanities.

5.3.2. Interactive research

The main task in this section is to evaluate the degree, to which Globaqua has advanced in terms of an interactive research dimension until now. Granted, two important steps have been taken so as to achieve the objective. First, an attempt to trace the trajectories of (intense) interactions between the different disciplines in the project was made during the interviews. Second, a large amount of attention was paid to trying to discover, whether research methods and theories, inherent to different disciplines, are being integrated in Globaqua (and if yes, to what extent).

First, with regard to the scale of interactions in Globaqua, Figure 10 depicts the initial collaborative Globaqua work plan, introduced in the DoW, which indicates the flows of interaction between different Modules and work packages.

Figure 10. Active interaction trajectories between the different Modules and work packages in Globaqua



Source: Barcelo (2013), and the qualitative interviews data analysis

Evidently, the collaborative work plan defines initially defined collaboration between different Modules for accomplishing both individual and collaborative tasks and deliverables of the project. With no exception, interviewees share a common agreement on the paramount importance of interaction with each other in the project:

"Interaction is fundamental for this kind of projects that are started to be interdisciplinary".

Having carefully processed the interviews data, as well as based on the overall observation, a conclusion in this respect can be drawn that the interaction since the beginning of the project up until 2016 June has been relatively intense. The subsequent grey arrows, illustrated in Figure 1, have been mostly confirmed by the respondents, and elaborated in a broader manner. To give an example, WP-3 has been mostly collaborating with WP-6, WP-7 and WP-9 for the chemical analysis, as initially planned. They have identified interesting topics for working together, and so far, this interaction is one of the successful examples of interdisciplinary collaboration in Globaqua:

"Overall, this is the most developed collaboration that I had so far in Globaqua."

Furthermore, several additional strands of intense interactions between different work packages have been discovered during the interviews. As they intensify the overall picture of interactions that have been taking

place in the first half of the project, the most elaborated collaboration pathways have been added to the official collaborative work plan. They are depicted by blue arrows in Figure 10 on top of the ones, initially set in the DoW prior to the start of Globaqua.

Proving that the collaborative pathways in in the project are active, and intense does not, however, ensure that an interactive research is present in Globaqua. Thus, it is essential to note that only if an interaction prevails among the different academic disciplines, it can be truly defined as an *interactive research*. In this respect, it means that collaboration within the Modules, and between the work packages within one Module, should be distinguished from an interaction between the different Modules, and the work packages from the different Modules. That is because the composition of a particular Module is mostly uniform in terms of disciplinary diversity (although not in all Modules), meanwhile, a variety in disciplines increases, when looking at the interaction between the different Modules. To give an example, WP-6 and WP-7 have been mostly working together, and the work packages are from the same Module. This case may imply that an interaction between fairly similar disciplines is not necessarily an interdisciplinary collaboration, even though it required a lot of interactive work. Nevertheless, Module 2 has also a close collaboration with Module 1, which, as a matter of fact, significantly increases the diversity of disciplines, working together (regardless the fact that most of the disciplines come from the Natural Sciences in both Modules). As a result, the interaction has a high potential to become an example of an interactive research. In fact, this exact case of an example of an interdisciplinary collaboration has been brought by several interviewees as an evident example in the project. To share the insight of one of the interviewees:

> *"There is a lot of interdisciplinarity between chemists and biologists from WP-4, WP-5, WP-6, and WP-7. Mostly, the research between these work packages is truly interdisciplinary".*

What it is interesting, is that a moderate proportion of the respondents has acknowledged the fact mentioned just above that not all interactions they have with the project partners is truly interdisciplinary. For instance, WP-8 has been mostly engaged in an active collaboration with the other two work packages from the same Module 3 (WP-9 and WP-10), as well as with WP-7, which is a neighbouring work package in terms of a disciplinary field. The way the interviewee reflected on it:

> *"I would not say it is a really exciting interdisciplinary science, but at least it is something."*

Based on the overall observation and evaluation, Globaqua seems to have a relatively intense interaction between the Modules, and the different work packages within these Modules. Therefore, the degree to which scientists have advanced, when speaking about the first aspect of an interactive research dimension – *A lot of interaction between different disciplines is present in Globaqua* – can be reasonably evaluated by 4 points, as 'relatively high'.

Second, what concerns the time spent on understanding other disciplines, a significant majority of the interviewees have admitted that during two and a half years of the project much time has been given for the disciplines to interact. Nevertheless, to what extent the time is spent for truly understanding other disciplines, is tricky to answer conclusively. On the one hand, if looking at the interaction pathways in the project, one may state that the opportunities for understanding each other are laid down, least in terms of

organisational structure, and they are relatively dense. On the other hand, several remarks made during the interviews indicate that no deliberate attempts for deepening the understanding between disparate disciplines in terms of their research methods and theoretical models have been made in Globaqua (at least, not on the whole project level). It is useful to mention that one specific activity for this purpose was organised in the mid of the first year of Globaqua – a workshop for getting to know participating disciplines better in the context of interaction between the modellers, environmental scientists, and empirical scientists (mainly chemists and biologists). Meant for an exchange of expectations and ideas for future collaboration in Globaqua, the workshop was not, however, successful as neither solid initiatives resulted, nor truly freewill participation was observed therein, according to one of the interviewees.

Yet, as the aim here is to assess the overall time spent on understanding different disciplines, regardless specific activities organized for this purpose, based on observation, 3 points can be assigned to this aspect of an interactive research. It is evident that there is quite some time spent on understanding different disciplines, however, the degree to which it is 'much', remains questionable.

Third, speaking about the other two aspects of an interactive research – integration of research methods, as well as of theories and models of different disciplines, it is important to focus of whether scientific practices are being integrated in Globaqua as a result of interactions (and to what extent they have developed thus far, if at all). This question can be answered, if looking at a group level collaboration, or the so-called 'first level integration', nicely described by one Module leader:

> *"It is the first level integration, which is the Science – so, it is what we measure, what we monitor, and see, what it tells about the environment".*

To be more specific, first level integration closely relates to scientific practices, inherent to academic disciplines in terms of research methods, concepts, and models they apply when approaching given questions and scientific problems. As such, it aims for integration of these scientific practices during the process of collaboration between disciplines, when interdisciplinary research is desired. Namely, interview respondents' opinion on whether Globaqua has advanced in this respect since the beginning of the project is not uniform. One prevailing standpoint, noted by nearly a half of the interviewees, is rather positive. When asked about the group level collaboration on specific tasks and deliverables, respondents admitted the deliberate attempts put by the scientists themselves to integrate scientific practices, being present. An insight, shared by a one of the partners in Module 1:

> *"We are trying to combine methodologies that are used in ecology with hydrological modelling. This is quite complex because <…> the tools are different".*

Respondents have also reflected on the collaboration between other than their own Modules:

> *"There is nice interaction between economists and scenarios developers. That is a good case of integration in the project".*

Yet, another opinion, when speaking about the first level integration, is quite opposite to the one discussed above. The rest of the respondents think that what has been going on in Globaqua up until now is no more than a fragmented multidisciplinary research. As one of the respondents noted:

> *"What is going on in Globaqua could be defined as 'multidisciplinarity', where different disciplines are working side by side, but there is no true integration".*

From the first sight, the above statement, if taken for granted, may raise serious concerns for both project management and the project participants. At the same time, having analysed the insights, shared by other respondents, as well as the DoW, it becomes definite that the overall Globaqua goal simply does not require theories and research methods of different disciplines to be integrated:

> *"The way Globaqua is designed, collaboration does not need to happen on a daily basis. For example, you let people develop their disciplinary perspective and knowledge, which contributes to the whole picture."*

As the above insight has been shared by a few respondents, it is evident that disciplinary inputs are, in fact, essential in Globaqua for addressing the specific aspects of the complex topic – integrated river basin management. In this way, various disciplinary work ideally covers and addresses the specificities of a complex topic at stake in order to compose a full picture of how the problem can be solved. This is a second level integration, which is yet to come in the second half of Globaqua, and will be addressed in Chapter 7. Meanwhile, according to a majority of Module leaders, the current level of scientific practices integration is at an acceptable level. To note:

> *"I just worry sometimes to see that people think there is a lack of integration in the project, when it is actually not. If you look at how Globaqua was designed, what is happening now in the project is correct and OK for this stage of the project".*

Hence, based on an extensive discussion on scientific practices integration, it can be fairly concluded that research methods are integrated to a 'moderate' degree (up to 3 points) as quite a few interactive activities have been undertaken in the project to align the different scientific practices in terms of research methods and data collection and processing. Meanwhile, based on the overall observation, a slightly lower degree of the integration of theories has been reached in the project, especially between disparate disciplines. The degree hence is no higher than 'relatively low' (2 points). Overall, interactive research currently in Globaqua amounts to 3 points on average, and is considered to be 'moderate' (see Table 10).

Table 10. Overall degree of interactive research in Globaqua

Dimension	Items	Score
Interactive research	A lot of interaction between different disciplines is present in Globaqua	4
	Much time is spent on understanding different disciplines in Globaqua	3
	Research methods from different disciplines are integrated in Globaqua	3
	Theories and models from different disciplines are integrated	2
	Total:	**3**

Source: Developed by the author, based on the interviews data analysis

5.3.3. Integrative understanding

Turning to the third interdisciplinarity dimension – integrative understanding, the discussion continues on the first level integration, defined in the previous section. The difference, however, is that instead of evaluating the integration of scientific practices, here the focus is rather on a different aspect. Namely, integrative understanding embraces a common understanding, shared concepts and frameworks that have been potentially developed between disciplines in Globaqua.

First, according to a significant majority of the respondents, there is a common understanding (or a vision) among project participants on the horizon. As such:

> *"I think, the one is emerging. It was actually designed to emerge. I do not think we are late in this – I think, people were meant to develop this about now".*

Granted, it can be stated that Globaqua has helped project partners in gradually developing a common understanding in the project, even though is not fully crystallized. This process has been nicely noted by one Module leader, who brought up a collaborative learning aspect:

> *"People actually develop this common understanding of the main topic, without even realising that. It has not, however, reached its peak – the point, where it becomes more explicit".*

The above statement has been acknowledged by nearly all interviewees that it takes a long time to develop a common understanding. Due to that, some concerns have been expressed by several respondents with regard to the lack of integration in the project. Nevertheless, if again looking at the overall expression from the interviews, and analysing the way Globaqua is designed, the middle of the project is about a proper time, when a joint vision rises. Under these circumstances, it has been achieved too a 'relatively high' degree in the project so far, amounting to 4 points out of 5.

Second, an important aspect has been touched upon in the previous citation. What is interesting is that scientists, participating in projects like Globaqua, are not able to grasp the exact moment, when their own understanding of a given issue starts transcending disciplinary boundaries, and that is thanks to a natural team learning process, enabled through interactions and joint activities. As a result of this (un)conscious learning process, shared concepts, as well as frameworks between disciplines emerge. To illustrate, this aspect was touched upon during the interviews:

> *"You do not really grasp this process going on because it goes slowly, and comes from a systematic disciplinary work in the project. In this sense, I think, people have already changed to some extent their views since the beginning of the project until know".*

From the overall observation, however, the tendency is evident that shared concepts have been developed well in the project up to a 'relatively high' degree (4 points), but this evaluation should be taken into account with reserve as, based on repetitive remarks been made by several interviewees, sometimes misunderstandings due to disciplinary language still come to the fore in the project. Nevertheless, a

significant majority of the interviewees admitted finally understanding their counterparts, as well as each other's expectations and needs in terms of collaboration. To note:

> *"I think, now we are beginning to understand each other, to perceive problems of the others". <…> We start having a more and more interdisciplinary vision of the project".*

Third, when it comes to evaluating the degree, to which Globaqua helped the participants to develop shared frameworks, it is more complex as this aspect was not broadly covered by a large proportion of respondents. Based on the collected data, however, attention to several remarks can be drawn. First, it is possible to state that a relatively high agreement currently exists among project partners on the future direction of collaboration, when speaking about scientific work:

> *"Now, there is a quite clear understanding among groups, and I would say, there is also a quite clear road map of papers that can be written by different disciplines".*

Then, an insightful idea has been brought up by one Module leader, which to some extent justifies the current Globaqua state: shared frameworks can eventually develop only, when trust among disciplines is developed. That is to say that not only it takes time to reach the stage of shared understanding and concepts among Globaqua partners, but it also requires mutual trust in disciplinary contributions to solving a given question. This idea has been put accurately in words:

> *"First, you have to have a good vision through your lenses, trust your eyes, and trust other people's eyes. You have to build your own capacity to understand, how the system from your perspective, before you are able to accept that others are also correct in their methodology".*

To sum up, only a 'moderate' degree (of 3 points) of shared frameworks could be said to be achieved among Globaqua participants, if focusing more on conceptual and not an organisational framework. Based on what has been observed from the interviews, it is possible to emphasize, however, that the degree is only moderate (and not higher) because it was simply not meant to develop in the earlier stages of the project, if looking from an organisation perspective. And in exactly this stage of the project the extent, to which shared framework is developed, is more than enough.

On average, Globaqua is observed to have reached a relatively high integrative understanding among project partners (3.6 points on average), even though the score is just on the verge of a 'moderate' degree as well. A summary of the scores on this dimension is provided in Table 11 below.

Table 11. Overall degree of integrative understanding in Globaqua

Dimension	Items	Score
Integrative understanding	Globaqua has helped in developing a common understanding up until now	4
	Globaqua has helped in developing shared concepts between the disciplines up until now	4
	Globaqua has helped in developing shared framework between disciplines	3
	Total:	**3.6**

Source: Developed by the author, based on the interviews data analysis

5.3.4. Effectiveness in advancing understanding

The last interdisciplinarity dimension relates to the overall effect that Globaqua has on advancing understanding of the participants, as well as on enhancing interdisciplinary learning. The core task hence is to evaluate the degree, to which Globaqua has been effective in this respect since the beginning of the project up until now. For measuring this extent, this dimension will be further analysed on its five composite items, introduced in the research design of this study.

First, the discussion begins with looking at a first-hand experience of Globaqua partners, as well as at their expectations with regard to scientific project outcomes. There is a dominant opinion in the project that Globaqua has already produced, and further generates valuable scientific work and outputs as most of the work that is being done in the project is from different disciplinary perspectives. Reflection on the overall scientific value of Globaqua work in the future was:

> *"I am quite happy with what is going on, and I hope that we will have interesting results".*

The overall observation suggests the same tendency – collective confidence in the project outputs in terms of scientific results is evident, and has been expressed by the respondents. Not only the results, according to them, are interesting, but also the experiments are useful, and the collected data is somewhat unique. Granted, it allows stating that the first part of this dimension has been already successfully fulfilled in Globaqua, and can be assigned the highest score of 5.

There is, however, a flavour of doubt prevailing among a significant portion of respondents that it is not so much likely that these valuable scientific outcomes will eventually be turned into decent policy recommendations. In this respect, some of the interviewees shared similar thoughts:

> *"I do not know, if we are going to deliver what we have wrote initially. <…> Maybe the description of work is a bit too ambitious, and overstates a bit what we are really going to produce. I would not say that Globaqua will change the policy on the EU level".*

A broader discussion on the potential that Globaqua has in significantly changing the EU policy arena, in fact, goes beyond the scope of this dimension, and transcends the reach of interdisciplinary research – it falls under transdisciplinary research, which is out of the scope of this study.

Second, with regard to the benefit that Globaqua brings, the interview results suggest a fairly similar expression – project partners acknowledge that the potential Globaqua has is higher than the burden it poses on scientific work and collaboration. Having acknowledged various challenges and difficulties that rise in Globaqua, a uniform positive opinion that it is worth an effort to have projects like Globaqua dominates. To name one of the advantages of such projects, one Module leader said:

> *"It takes time at the beginning of the project, but I still believe more in this type of projects like Globaqua. Its outputs are comparable, and the opportunity to compare is important"*

Given a common agreement among Globaqua partners that IDR projects are indeed valuable (and in most cases the only way to address complex problems), it should be noted that several respondents spoke up for

having both types of projects (interdisciplinary and multidisciplinary) as they both have distinctive benefits. Nevertheless, when assessing the added value of Globaqua over the burden it poses, general opinion is strongly positive, and can be fairly assigned a degree of 'high' (5 points).

When turning to the third aspect of this dimension – interdisciplinary learning, tit has been acknowledged during the interviews with no exception. From the first sight, this 'learning between disciplines' may seem to be natural, and sound even trivial. To illustrate:

> *"I think, people learn from each other, they get to know new things from other disciplines".*

Yet, if given more attention, interdisciplinary learning is actually a much more sophisticated process that has a potential to unfold only in the projects like Globaqua. Not only it suggests getting to know new things from other disciplines, but is also means becoming aware of the scientific practices of other disciplines. An insightful explanation of this process is has been shared by one Module leader:

> *"Learning means understanding other disciplines. <…> You need to know the state of the art of their models and methods, to be aware of the major aim of other disciplines, and how these aims connect with the major aim of your discipline".*

Given this explanation, two respondents shared a similar observation about their colleagues:

> *"They are becoming more aware of the different conceptual approaches of other disciplines. They see, how what they do, is different or complementary to what everybody else does".*

In addition, if looking more generally, learning between disciplines in Globaqua is seen as an added value of such projects, which is also contributing to scientific outcomes. To note:

> *"That is, probably, one of the main values of this type of projects because you force hydrologists to think in terms of ecology or economics".*

An important remark has been made that to observe and experience this learning process is rather difficult, if looking at the project level. In contrast, interdisciplinary learning is more evident on a group level in Globaqua, when specific tasks are to be done through interaction between different disciplines. And most accurately it has been put in words by one scientist in respect of this aspect:

> *"We all learn through disagreements in terms of looking at the same object from different perspectives. As long as people understand and respect that, I think, it works".*

Having extensively reviewed interdisciplinary learning in Globaqua, one can conclude it being present to a 'relatively high' degree at the moment (amounting to 4 points).

The fourth aspect refers to the level of appreciation of other than one's disciplines in Globaqua. Several important, and satisfactory ideas have been brought up by a majority of the respondents during the interview. Firstly, a highly positive reflection has been expressed with regard to the willingness of Globaqua colleagues to pay attention to the ideas and input of others in the project:

"I always find people willing to listen to what others are saying, and, also, it is very much interesting to understand and listen to what they are saying".

Given the fact that Globaqua has a high disciplinary diversity, one can say that people are willingly listening to their counterparts, representing these different disciplines. Secondly, some respondents admitted finding it enriching to see, how other disciplines approach the same problems. When talking about the collaboration between modellers and social scientists, a work package leader said:

"I am liking very much how they approach each other, and we can learn a lot from that".

Thirdly, the most essential aspect has been acknowledged by a majority of Module leaders –interdependency that actually are inevitable in Globaqua. Interdependency, mainly in terms of resources – data, to name the most important one. This idea has been mentioned by several people:

"A lot of partners in Globaqua know that with their own data they will not have substantial results. So, they need to collaborate".

With this in mind, it can be stated that other disciplines in the project are appreciated. Yet, it is tricky to assess the degree, to which the appreciation has been achieved in Globaqua as only a few respondents actually brought it up. A 'moderate' degree is, thus, appropriate to be assigned.

Finally, with regard to the last aspect of the dimension – *integrative understanding of water issues*, no judgement can be made in this respect as neither this aspect was brought by the respondents, nor it is actually possible to assess to what extent Globaqua has improved integrative understanding in this sense because the second level integration will only start in the upcoming months. Therefore, a decision has been made not to include this item in the overall evaluation of the effectiveness of Globaqua in advancing the understanding within the project.

Overall, the dimension has reached a 'relatively high' degree of 4.25 points on average (see Table 12).

Table 12. Overall degree of effectiveness in advancing understanding in Globaqua

Dimension	Items	Score
Effectiveness in advancing understanding	Interdisciplinary research among Globaqua participants leads to valuable scientific outcomes for river basin management that would not have occurred without collaboration	5
	The benefits of interdisciplinary research within Globaqua outweigh the inconveniences and costs of such work	5
	Globaqua has helped to learn from other disciplines	4
	Globaqua has improved the appreciation of other disciplines	3
	Globaqua has improved an integrative understanding of water issues	-
	Total:	**4.25**

Source: Developed by the author, based on the interviews data analysis

5.4. Reflection on interdisciplinarity part of the model

Having reviewed the results on the dependent variable of this research from both data sets, some reflection on the *content* part of the conceptual model – scientific knowledge integration in Globaqua is to be provided. First, the overall picture of interdisciplinarity, and second, the way of measuring its progress are discussed in the sub-sections below.

5.4.1. Combining the results: the overall picture of interdisciplinarity in Globaqua

Building upon the two previous sections – 5.2. and 5.3., it is necessary to establish the link between the quantitative and qualitative analyses. For this purpose, the overall scores on each interdisciplinarity dimension will be compared, by addressing certain differences between the scores, as well as by trying to explain some of them, according to both data sets.

With regard to the first interdisciplinarity dimension – the scope of IDR, no substantive differences to be discussed have been observed as both the survey results and the interviews depict a fairly similar picture – a wide range of disciplines from Natural Sciences, and some from Social Sciences fields are involved, and actively participating in Globaqua. To add, the trend that a dominant group of natural scientists took part in all seven meetings analysed has also been observed in the sample of the interviews: nearly all the respondents possess their education in the Natural Sciences field, and only a minor portion of the respondents have a mixed disciplinary background in both Natural and Social Sciences. It is, therefore, fair to conclude that the Globaqua partners are dominantly representing Natural Sciences, and only to a minor extent – Social Sciences.

Looking at the overall picture of the scores on *interactive research* dimension, a considerable difference can be observed, if comparing quantitative and qualitative results. The survey results, as noted in Chapter 5, discover a gradual increase on the interactive research dimension between the same types of meetings. The results, however, show perceptibly higher degrees of interactive research reached in the first up to the seventh meeting than the interviews results. The latter suggest the dimension to be advanced only to a moderate degree as of 2016 (for the scores, see sections 5.2.2. and 5.3.2. respectively). The reason, why the overall score, assigned to this dimension based on the qualitative data is only 3 points, is because the investigation of the constituent items of this dimension during the interviews turned out to be more comprehensive than it was expected. When asked about interactive research, the respondents outright depict it highly positively. Yet a more complex reflection came to the fore, when questions in relation to an integration of research methods, or theories and models from different disciplines in Globaqua were asked. This observation allows generalising that the survey respondents may have assessed this dimension in a rather too simplistic way, neglecting the complexity behind its constituent items just mentioned. Having said that, it is no surprise, why the score on the interactive research dimension amounts to 3.7 on average in the very first project meeting, and during the later Globaqua meetings. In contrast, the overall assessment from the interviews is slightly different due to the fact that the complexity of this dimension has been

comprehensively discussed. This matter is to be further elaborated in Chapter 7, when the distinction between the first and the second level of integration is to be broadly addressed.

Speaking about the *integrative understanding* dimension, a nearly identical expression as a consequence of comparing the scores on it is evident. The survey data indicates a marginal increase of the degree of this dimension between the same types of meetings along the timeline. Yet, if compared to the qualitative data results, slight differences are present: although both data sets indicate a 'relatively high' degree (including the results from all seven meetings), the scores differ in their numerical expression. For example, in the last General Assembly, Sampling campaign and Module meeting the scores are 3.9, 4.6, and 4.2. respectively, whilst the overall evaluation made as a result of the interviews scores 3.6 on average. Yet, it can be stated that the overall assessment of integrative understanding from both data sets is relatively similar.

The results on the *effectiveness in advancing understanding* appear to be similar as in the case of integrative understanding dimension – the scores from both analyses are of 'relatively high' degrees, amounting to 4.25 points and higher on average in the last meetings of all types (with an exception of a 'high' degree of 4.9 points on average in the second Sampling campaign). It should be noted, however, that in the qualitative analysis, the score assigned to the fourth dimension is the lowest, compared to the scores from the meetings. This finding implies the same tendency: although the scores from both analyses are relatively similar, the interview results in scores are somewhat lower, compared to the survey results.

Following the last statement that interdisciplinarity scores somewhat higher in surveys results than the overall assessment from the interviews. The biggest difference in scoring is observed in terms of the interactive research, generally, due to the reason of oversimplification of this dimension from the perspective of the survey respondents, as discussed above. The more alike evaluation appeared in the cases of the integrative understanding, and the effectiveness in advancing understanding dimensions (although in terms of the scores, the former dimension indicates more similar scores than the latter, which shows somewhat bigger differences in scores).

Having compared the scores on interdisciplinarity, as well as emphasized some of the intricacies of the differences, a general assessment of the evolution of interdisciplinarity in Globaqua is that scientific knowledge integration progresses in terms of the second, third, and fourth dimensions. Yet, the evolution of these dimensions takes place not in a sequence of one after another, but rather simultaneously from the beginning to the end of the project. As such, effectiveness in advancing understanding has been discovered not to be a final stage of interdisciplinarity. Conversely – it is evolving throughout the life-course of Globaqua in parallel to the other two dimensions.

When it comes to comparing quantitative and qualitative analysis results, it is evident that discrepancies between the different data sets in terms of the overall scoring on interdisciplinarity dimensions are observed. This likely implies that measuring the degree of interdisciplinarity from the perspective of a single method may misrepresent the real picture, or reveal only part of it. To prevent this, measurement of interdisciplinarity progress is to be detailed further.

5.4.2. Measuring a progress of interdisciplinarity in Globaqua

Building upon the previous section, the added value of this study is combining and comparing in between the survey and the interview data, when measuring interdisciplinarity progress in Globaqua. Triangulation of research methods has enabled justifying the quantitative analysis results with qualitative data analysis, and has eliminated, or compensated certain limits of the survey data. Elaboration on these limitations, coupled with strengths of a statistical measuring of interdisciplinarity progress, is detailed below.

First, the Globaqua surveys were designed for evaluating interdisciplinarity in the three different types of meetings, and that makes the collected data not fully comparable because the meetings significantly differ in their organisation, objectives, nature of work and tasks, as already noted. Consequently, tracing the overall evolution of interdisciplinarity in a consecutive manner is limited to the extent of looking at the scores between the same types of meetings. So, although in all types of meetings all three interdisciplinarity dimensions progressed, the findings are not conclusive on the overall project level as comparisons are made only between two meetings of the same type (with an exception of three Module meetings).

Second constraint relates to the credibility of the survey data in terms of the ratio of the respondents. In total, 111 unique codes have been counted from all completed surveys. By tracing the codes between the same type meetings, it has been discovered that 38% of the respondents of the first General Assembly participated in the second General Assembly, and only 6% of the respondents of the first Module meeting participated in the second and third Module meetings (see Appendix 1). Sampling campaigns are an exception as the participation in them is not meant to overlap. Consequently, drawing generalising remarks on the observed progress in scores on interdisciplinarity dimensions in all three types of meetings has to be made with caution as it may have been caused simply by the fact that new participants rate interdisciplinarity higher, compared to the respondents in the earlier meeting of the same type.

Third, a limitation of the credibility of the survey data is that it does not encompass the discussed distinction between the two different levels of integration. The developed constructs of interdisciplinarity dimensions cover only the first level integration – scientific practice and knowledge integration process, leaving the active integration of scientific inputs and results in the project out of reach in the survey. This distinction has been discovered during the interviews, and the second level integration has been acknowledged as an important subsequent stage of interdisciplinary collaboration in Globaqua. Yet, excluding it from the survey is likely to affect the overall scores on other three dimensions as the respondents may be referring to it, when asked to evaluate *integration* of research methods, or theories.

Altogether, the above discussed drawbacks of the survey data have been redressed by employing a qualitative research method – interviews with Globaqua partners. Not only a more integral overall picture of the project in terms of scientific knowledge integration has been revealed, but also insightful findings have been discovered in addition to the survey data results. Yet, to identify the limitations of the survey data is not to deny its reliability in terms of the constructs, developed in the questionnaires. Statistical scale reliability tests have been run for the three dimensions on the data from all seven meetings in part (see Table 13). To specify, the construct of effectiveness in advancing understanding demonstrates the most satisfactory

internal scale results: a reliability coefficient ranges from 'acceptable' to 'excellent' (Cronbach's Alpha = 0.729 < α < 0.97). Similarly, reliability of an integrative understanding construct ranges between the same levels (Cronbach's Alpha = 0.709 < α <0.963), with an exception of a 'questionable' value (α = 0.606) in the first Module meeting. Lastly, interactive research construct indicates two errors: data from the second Module meeting shows 'poor' reliability (α = 0.522), whilst the second Sampling campaign signals 'unacceptable' construct reliability (α = -0.194) due to a negative average covariance among items, which violates reliability model assumptions. Regardless these errors, all three constructs are highly reliable, and can be employed, or developed further in future research on measuring interdisciplinarity.

Table 13. Descriptive statistics on the three interdisciplinarity dimensions in Globaqua meetings

Meetings	Interactive research			Integrative understanding			Effectiveness in advancing understanding		
	M	**SD**	**Cronbach's Alpha**	**M**	**SD**	**Cronbach's Alpha**	**M**	**SD**	**Cronbach's Alpha**
General Assembly (2014 November)	3.7	0.72	0.71 (acceptable)	3.6	0.79	0.83 (good)	3.6	0.79	0.97 (excellent)
General Assembly (2016 January)	4	0.64	0.776 (acceptable)	3.9	0.68	0.878 (good)	4.3	0.54	0.869 (good)
Sampling campaign (2015 July)	4.3	1.01	0.757 (acceptable)	4.4	0.88	0.963 (excellent)	4.4	0.97	0.941 (excellent)
Sampling campaign (2015 September)	4.9	0.32	-0.194 (not acceptable)	4.6	0.65	0.949 (excellent)	4.9	0.36	0.911 (excellent)
Module meeting (2015 May)	3.6	0.66	0.79 (acceptable)	3.9	0.51	0.606 (questionable)	3.9	0.56	0.745 (acceptable)
Module meeting (2015 November)	4	0.53	0.522 (poor)	4.1	0.51	0.709 (acceptable)	4.2	0.44	0.729 (acceptable)
Module meeting (2016 April)	4.1	1	0.921 (excellent)	4.2	1.1	0.941 (excellent)	4.5	0.51	0.866 (good)

M – *Mean score*
SD – *Standard deviation*
Cronbach's Alpha – *Construct reliability coefficient*

Source: Developed by the author, based on the statistical data analysis

To conclude, this section has provided substantial research insights on measuring interdisciplinarity progress. Yet, the core argument in this study is that taking a detailed look at the socio-cognitive processes and properties of interdisciplinary collaboration among project participants is crucial in order to obtain the full picture of interdisciplinarity in IDR project. Thus, factors and conditions of different types, influencing interdisciplinary collaboration in Globaqua are elaborated in Chapter 6.

Chapter VI: Investigating interdisciplinary collaboration in Globaqua: influencing factors

As this research had a two-fold objective – not only to measure the degree of interdisciplinarity in Globaqua, but also to investigate the factors and conditions of various types, holding an influence on the process of interdisciplinary collaboration in the project, this chapter will provide an extensive discussion on the results from both quantitative and qualitative data analyses, with regard to the affecting factors. By doing this, two research sub-questions are expected to be answered in turn:

- What are the factors and conditions of various types, influencing interdisciplinary collaboration in Globaqua?
- What type of managerial strategies enhance interdisciplinarity in the project?

First, the presence of *professional*, *individual*, and *structural* types of factors will be discussed in the Globaqua context, by distinguishing the effect they have on interdisciplinary collaboration, according to both survey and interview respondents. In addition, collaborative team environment will be then addressed in terms of its main influencing elements – *atmosphere* and *challenges.* Second, the discussion on the presence of different types of managerial strategies will then follow, also touching upon the influence they have on interdisciplinary collaboration. Notably, when the quantitative data is invoked, descriptive statistics on certain variables are to be indicated. Lastly, a reflection on interdisciplinary collaboration part of the model will be substantiated.

6.1. Professional type of factors

6.1.1. Disciplinary background

The first factor to be elaborated is *disciplinary background* of scientists involved. Disciplinary diversity serves as a pre-condition for interdisciplinarity to emerge, and is not *de facto* a problem in Globaqua, but conversely:

> *"In Globaqua, everybody is understanding different cultures, backgrounds, disciplines, and experiences".*

The respondents agree, however, that issues with regard to different disciplinary education of project partners often come to the fore. For example, one of the issues relates to the different scales that Natural and Social Sciences are used to work with. To quote an insight, shared by a natural scientist:

> *"We are struggling a little bit with the understanding of scale and of catchment that social scientists have".*

Furthermore, differences in disciplinary background spotlight the specificities of working of certain disciplines in Globaqua. One of the instances relates to the economists as those, who tend to take over the control of their collaboration with other partners and/or work packages:

> *"The economists see themselves as the specialists that come on top of a scientific, or a social process as an external contribution. They get less engaged with the overall thing".*

Notably, this example relates to the Economics per se because it has been named as the discipline that "needs to become more interdisciplinary", and to understand collaboration less as a process of directing, but more of "a feedback across the disciplines". Moreover, while the economists were named as too directing, chemists were identified as too closed in terms of scientific work: although their contribution to Globaqua results was commended as truly significant, they are seen as not much engaged in working on the interfaces with other disciplines, but rather as performing independently from other Globaqua partners.

Finally, considerable differences have been observed in the evaluations of interdisciplinarity dimensions in the survey results, when distinguishing between the respondents with different disciplinary background. Although the mean scores on interdisciplinarity, given by the different type of scientists in all seven meetings, do not indicate one prevailing trend, evident differences can be yet highlighted. To delineate, social scientists have rated roughly all three interdisciplinarity dimensions with the highest scores in both General Assemblies and the first two Module meetings (with an exception of one dimension in the second Module meeting). In contrast, the lowest scores in both General Assemblies (with an exception of one dimension in the second meeting), as well as in the second Module meeting were given by the Engineering scientists. What is interesting though is that unlike in both General Assemblies, engineers gave the highest scores on interdisciplinarity in the first Sampling campaign, and vice versa – the only participating social scientist rated interdisciplinarity dimensions the lowest, compared to all other participants. Notably, no social scientists participated in Sampling campaigns, thus, the highest scores in both Sampling campaigns were given by the engineers, Life, and Environmental scientists.

Although the scores by disciplines differ per each meeting, a generalising finding can be drawn from the results of the statistical analysis from both General Assemblies, when looking at the scores on interdisciplinarity by the *type of scientist.* Namely, in both meetings social scientists have rated interdisciplinarity dimensions unexceptionally higher than the natural scientists. The overall summary of the means on interdisciplinarity dimensions can be found in Appendix 2 in accordance to all seven meetings.

To sum up, disciplinary diversity poses a number of barriers, when collaboration between the different academic disciplines is to take place. The greatest effect, however, is of a much larger scope – disciplinary background causes misunderstandings between the different disciplines due to an inherent scientific language used. The main challenge, as a result of differences in disciplinary backgrounds of the involved scientists in Globaqua, is to be further addressed in section 6.4.2.

6.1.2. Prior interdisciplinary experience

When assessing the relevance of having *prior experience in IDR* to interdisciplinarity, it is also necessary to distinguish between the insights, shared during the interviews, and the statistical analysis results. In the former case, the prevailing opinion among the project partners is that having previously taken part in interdisciplinary endeavours positively affects one's participation and collaboration in future projects. This statement is not conclusive yet because the respondents have also expressed two related remarks. First,

scientists, having prior experience in IDR, mostly know the difficulties with regard to bureaucratic organisation of the projects like Globaqua:

"They have a lot of experience in how the deliverables should be delivered, or how the money should be spent. They are not having surprises in this sense, whilst others with no experience have these surprises".

Second, agreeing with an idea that prior IDR experience makes collaboration smoother is not to say that the colleagues with no (or less) experience in IDR are less collaborative or knowledgeable:

"You can work smoothly with people with no experience – you just have to mark the path more clearly".

Overall, interviews data suggests a uniform positive opinion that prior experience in IDR fosters interdisciplinary collaboration. Meanwhile, with regard to the survey data, it can be stated that the survey respondents across all seven project meetings overall were relatively experienced in IDR prior joining Globaqua: the average of the experience ranges from 7 to 10.7 years (see Table 14). Yet, the results should be taken into account with caution as the Globaqua partners are experienced in IDR very unevenly: experience varies from no to 35 years, implying a high diversity of Globaqua partners in this sense.

Table 14. Average prior experience in IDR of the Globaqua survey participants

	General Assembly (2014 November)	**General Assembly** (2016 January)	**Sampling campaign** (2015 July)	**Sampling campaign** (2015 September)	**Module meeting** (2014 May)	**Module meeting** (2015 November)	**Module meeting** (2016 April)
Survey sample size (N)	N=42	N=45	N=16	N=13	N=18	N=27	N=27
Average length of prior IDR experience (in terms of years)	10 years	9.3 years	7 years	12 years	8.4 years	10.7 years	8.3 years
Standard deviation (SD)	7	7.92	7	9.5	5.62	6.44	8.82

Source: Developed by the author, based on the statistical data analysis results

Moreover, if trying to draw some generalising remarks in evaluating interdisciplinarity degree in different meetings, based on the survey participants experience in IDR, no evident trends can be observed – assessments of all three interdisciplinarity dimensions highly vary per various groups of experience in IDR across all seven meetings. For the sake of looking at different meetings results, see Appendix 2.

6.1.3. Other professional type of factors

Several other professional factors have been named by the respondents. First, *availability* of the scientists in Globaqua is essential, and is often a barrier to interdisciplinary collaboration:

"There is always this constraint of resource – the availability, and especially, the availability of the best scientists in terms of their scientific profile".

Further, coupled with prior experience in IDR, *confidence* in what project partners do is also an essential factor in the context of interdisciplinary collaboration, according to several Module leaders:

> *"Having previous experience matters a lot – you are experienced in interdisciplinary projects, and you are confident in what you do, which is also very important".*

Finally, *positive experience of working together* as a result of previous professional endeavours, when speaking about a group composition, has been mentioned by nearly all respondents as facilitating interdisciplinarity collaboration the most. To note, the fact that the Globaqua Consortium is composed of the people, mainly coming from the two previous interdisciplinary projects of a large scale – 'Climb' and 'Aquaterra' has been brought up during the interviews. As a result, most of the project partners have already worked with each other in the past, and have acknowledged having a good working relationship. When giving an instance of successful interdisciplinary collaboration in Globaqua, interviewees highlighted the fact that the partners from WP-4, WP-5, WP-6, and WP-7 know each other from the past, and this hence enables more fruitful interaction between these groups:

> *"Most of the research between those work packages is truly interdisciplinary because there is a long-term relationship between the groups".*

To conclude, from all the above discussed factors of a professional type, the most significant ones are educational disciplinary background and having positive previous working experience with each other, when speaking about the different partners involved in the Globaqua Consortium.

6.2. Personal type of factors

In Globaqua, disciplinary variety is inevitably accompanied with a diverse group of project partners, in terms of geography, culture, languages, and personalities. A given composition of the Consortium is in this respect is facilitating interdisciplinary collaboration, according to the interviewees:

> *"If we are all similar, we will not have a good project, and if we have similar perspectives, it would not be better. Globaqua in this respect is positive as the diversity is reflected very well".*

Granted, taking a closer look at what concrete personality aspects come to the fore during collaboration in Globaqua may suggest useful insights. Two factors – *willingness* and *flexibility* – have been recurrently brought up by the respondents.

6.2.1. Willingness

When speaking about the willingness of Globaqua partners, it is necessary to distinguish between personal motivation and professional gains. In the case of the former, based on the observation, Globaqua partners favour the topic of managing the freshwater basins, threatened by a variety of stressors: not only they demonstrate a genuine interest in the context, but some of the interviewed leaders have also expressed the need to make the water issues more apparent on the EU level:

"The European Commission does not have a priority in water anymore: water now goes under the climate change. We should invest in making the water more visible in the agenda of the European Commission".

Also, the fact that the Consortium has the leading scientists in the field, selected according to their expertise and knowledge, it can be fairly stated that the scientists are personally interested in Globaqua subject. This interest is also accompanied by an inclination of the Globaqua partners to engage in enriching scientific discussions with their counterparts, according to a majority of the respondents. Overall, the Consortium seems to have a general scientific inclination to pursuing Globaqua goals, and their persistence. Yet, a remark made by one respondent should be noted – sometimes there is not that much of a personal interest in the topic as an ordinary need to have a continuous professional placement, and Globaqua is one of these.

What concerns the professional gains, a uniform generalisation is not possible as a two-fold answer prevails, given by a large proportion of the respondents. On the one hand, personal expressions during the interviews suggest that some of the project partners strive for achieving Globaqua objectives due to either personal or scientific incentives, or both. On the other hand, as the main goals of Globaqua are neither so much clear nor mandatory on the project level, there are perceptibly low group efforts in truly achieving the Globaqua objectives. Instead, disciplinary or small-scale collaborative goals dominate over the common project goals.

Finally, speaking about the aim to expand one's professional network, when participating in Globaqua, again, more or less a homogenous opinion prevails: the project leaders believe in the high profile of the project, and also they acknowledge it as a fruitful network that enriches scientifically and professionally. To illustrate:

"To be part of a network is tempting, and, also, valuable in many ways".

Generally, there seems to be much willingness in terms of both personal motivation and professional gains in the Globaqua Consortium.

6.2.2. Flexibility

When assessing the flexibility of Globaqua participants, no exceptional remarks were made during the interviews, suggesting other than a positive evaluation. Project partners, when speaking about themselves, or reflecting on the work of their counterparts, indicated that adapting to organisational changes in terms of schedules or specific tasks, is mostly smooth, and causes no crucial difficulties to the ordinary project work. As such, Globaqua Consortium seems to be a highly versatile group in this sense. Yet, there has been one concern raised with regard to adapting to the set time frames for delivering particular tasks, and because this issue relates to the organisational setting of Globaqua, it will be further addressed in section 6.3.3.

Altogether, personal type factors do not seem to be of a high influence, when speaking about interdisciplinarity in Globaqua. More of a general observation can be made that personalities do matter, according to the project partners: being inviting personality, not shy, and open-minded surely facilitates interaction among the participants. Yet, these factors have not exerted crucial impact in Globaqua up to date.

6.3. Organisational type of factors

In this section, the organisational design of Globaqua is to be discussed for the purpose of assessing, whether it is facilitating interdisciplinary collaboration in the project, or conversely – some of its aspects in terms of the structural and/or organisational arrangements to some extent hinder interaction between the project partners. For this purpose, the overall assessment of Globaqua organisation will be made first, based on the DoW and the interviews data. Then, four types of *structural and organizational* type of factors and conditions will be addressed in accordance to the conceptual model – *joint activities, enough time, and clear tasks and goals*, as well as several additional remarks, brought up by the respondents, will be invoked in the discussion.

6.3.1. Overall organisational design of Globaqua

Given the size of Globaqua, and the demands for sound communication, required for the decision-making mechanisms, particular attention is paid to frequent internal progress reports in the project. Thereupon, this sub-section aims at exploring the channels that an organisational Globaqua design provides the partners in order to ensure the effective communication and information flow. The DoW has set the internal communication to be structurally enabled mostly by internal progress meetings, review meetings, and technical work package meetings, also, by conference calls and emails (Barcelo, 2013). While the official meetings of Globaqua will be discussed in the next sub-section, an organisational arrangement of Globaqua has been actually confirmed in terms of effective communication flows and interaction among project partners, when having extensive interviews with the project partners. Depending on specific tasks and deliverables to be completed, the main channels for internal communication in Globaqua are *Skype calls*, *phone calls, emails*, and *Skype meetings*. Less often used ways of communication are *small-scale meetings in person* around the official project meetings, planned in advance. Generally, the respondents have unanimously noted the presence of frequent contact moments among various Modules and work packages.

Some controversial insights, however, come to the fore, when assessing the overall organisational setting of the project. One of the remarks made was that the way Globaqua is designed is perfect for engaging in IDR. That is because the project, first of all, looks at the natural system together with a range of Natural Sciences disciplines, and then, aims for integration with Social Sciences. To clarify:

> *"One of the good things of Globaqua is the way it was designed – in an interdisciplinary way. Although it requires the disciplinary input <…>, it acknowledges that this is part of the story, and that it is the integration of those that gives the interdisciplinary nature of what we want."*

To the contrary, an opposite perception of the Globaqua design has been expressed by several respondents, concerning the logic of the collaborative work plan:

> *"The logic in the project would be much easier, if the Module 1 works for the first year, then, the Module 2 joins, and also Module 3, Module 4, and Module 5 in turn".*

Yet, this is not the case in Globaqua, so, quite many difficulties emerge in the course of the project due to this logic: delays in delivering some tasks, in exchanging information, in producing results, to name a few. As

a result of such interdependent arrangement of the project work, certain working discomfort is caused quite frequently, although it is not crucial in a way.

The last remark to be noted is the administrative burden that the organisational project setting poses to the daily work. This observation has been made by the Module leaders, when elaborating on the intense reporting they have to do in Globaqua. Instead of focusing on what they actually have to solve during their participation in Globaqua, scientists feel like wasting time on writing reports, and submitting them to the coordinator prior being able to finally submit them to the Commission: up to 200 scientific papers have to be produced by the Globaqua Consortium in total. As such, administrative technicalities cause "pressure" and overhead: "people are trying to work on publications, rather than solving the scientific questions first".

6.3.2. Joint activities

Official Globaqua meetings

Given the complexity of the collaborative Globaqua work plan, the main official project meetings are *General Assemblies*, *Module Meetings*, and *Sampling Campaigns*, expected to significantly contribute to enhancing scientific knowledge integration among and within Modules and work packages in the project (Barcelo, 2013). This needs further elaboration, based on both quantitative and qualitative data analysis.

First, an assessment of the added value General Assemblies have in enhancing interdisciplinarity in Globaqua is two-fold. On one side, Assembly is the most formal out of three types of meetings, and is often referred to as "too old-fashioned" due to the presentations each work package has to give in turn during the meeting. Also, because no essential discussions emerge, and no relevant questions are being addressed there: General Assemblies are "not useful to discuss science".

On another side, General Assembly is considered to be exactly the format that Globaqua needs once a year for reviewing the results on a project level. According to a large proportion of the respondents, there is no need for bringing all the issues to the General Assembly – the meeting is rather important for further planning of collaborative work:

> *"General meetings are beneficial as they help to identify critical points and problems, and to make arrangements for future discussions".*

In this respect, the specific moments of identifying core moments of Globaqua that need attention, the discussion, according to one Module leader, is relatively interdisciplinary:

> *"Everybody speaks not from the perspective of their specific discipline, but are curious about understanding the implications of some other findings in the perspective of other disciplines".*

Furthermore, being prepared for the General Assembly in advance ensures the successful course of the meeting. This means both – preparing in terms of one's tasks and deliverables with other project partners, as well as knowing to whom it is necessary to talk to with regard to the further work in the project. Taking all arguments into account, it is evident that General Assemblies are not actually meant to promote integration.

They rather provide project partners with an opportunity to see, how the specific inputs from different disciplinary work can be integrated with others in the project.

Second, the Module meetings are in principle different to General Assemblies as they are designed for discussing internal Module-related questions, for example, an interaction between the work packages within one Module. The meetings, led by Module leaders, are meant review and reflect on the overall internal progress within a particular Module. In this sense, Module meetings are not fostering interdisciplinary collaboration in the project that much as real integration mostly happens on the interfaces between different disciplines, or between different Modules as of Globaqua, according to a majority of the interview respondents. And in the Module meetings that is difficult:

> *"We never have a chance to discuss with the people from other Modules as there is no time during the meetings, and there is no discussion on how to integrate things from Module 1 to Module 2, or Module 3".*

As "there is no real time for people to present or to propose initiatives", meetings of a single Module do not facilitate discussions on core points in the project. The situation changes, however, if the meeting is arranged on an inter-Module basis, the respondents say because sometimes too much time is given to the Module meetings for discussing the issues of single Modules. This poses a risk in focusing too much on the integration within the Modules, and limiting the whole project integration. Consequently, project partners favour the idea to organise Module meetings in a more open fashion, allowing all the interested parties to participate. Of course, widening the participation too much might also be dangerous, so, keeping the balance in this respect is important:

> *"If you widen the integration too soon, you may run in to the risk of not actually having a common understanding of the language of different disciplines within the Module".*

It is, therefore, a task for both Module leaders and the project management to unveil the potential that Module meetings are designed to have in Globaqua in fostering interdisciplinary collaboration.

Third, the Sampling campaigns have an absolutely different objective in Globaqua: to carry out the case studies in the six river basins in order to collect vast data in there. Also, Sampling campaigns differ in terms of an organisational setting because the participation in the meetings is determined by the particular case study to be implemented. Granted, there is no overlap in the attendance of Sampling campaigns, so, expectedly, the meetings are relevant not to all Modules and work-= packages in the project. For instance, for the scientists from Module 3 the importance of Sampling campaigns to their work is relatively low, and contributes only to a little extent – to the results of the preceding work packages, which data the Module 3 uses in its work.

Regardless, Sampling campaigns have been acknowledged as the meetings that facilitate informal relationship building in Globaqua the most, compared to General Assemblies and Module meetings. With regard to enhancing interdisciplinarity, however, the interviews show the contrary results – Sampling campaigns "help on a number of aspects, but not necessarily on the scientific advancement" because the

work there is focused to limited number of specific aspects, and are mostly concentrated on the case studies, at times lacking the link with the project level integration.

Informal moments of contact

Along the official Globaqua meetings, project partners have a number of informal contacts in Globaqua. With no exceptions, non-official interaction in the project has been named as essentially contributing to interdisciplinarity. Topic-related workshops, small-scale meetings in person, several days visits, and even coffee breaks, or dinners are the examples of joint activities, in which informal Globaqua collaboration takes place, and partners "find a way to raise questions that maybe do not come up in a more structure circumstances". To reflect on this:

"These sort of things are making us cross the boundaries between the disciplines".

In this respect, a relatively high degree of self-organisation has been observed to be taking place in Globaqua. Project partners take initiatives in establishing links with each other, where necessary, and mutually enhance scientific work in the project.

Moreover, a very useful and in some cases the most developed informal interaction has been mentioned the 'off-the-record' collaboration among some of the project partners: new project proposals, joint articles, or attending and addressing various conferences, just to name a few. Although these side activities are not related to Globaqua work, they are nice examples of how people expand their occupation based on both professional and personal trust among each other. The only one risk of having side activities is that a micro-climate might emerge between certain groups, and may result in losing the overall picture of the project work. It has not, however, been acknowledged as a current issue in Globaqua yet.

Altogether, joint activities in Globaqua are highly frequent, including both formal project meetings, and informal interactions and moments of contacts as a result of successful self-organisation initiatives in the project. If juxtaposing formal and informal activities, the latter have been acknowledged as much more essential to interdisciplinary collaboration because the official project meetings due to a tight schedule do not provide time for discussing face-to-face subject-matter questions, which in most cases are the most needful at a time for further scientific work. Yet, the need for formal project meetings is definite – only the organisation and course of these meetings may be improved in the future.

6.3.3. Enough time

It is no wonder that the time frame that Globaqua partners have for delivering their tasks, and producing the deliverables has been named as "not sufficient". Given the fact that Globaqua comprises a wide range of different activities, related to specific tasks and collaborative deliverables, the overall project plan has put a burned on a daily work of the partners. That is not only because differences in disciplinary language and practices takes up a large portion of time (see section 6.4.), but also because the collaborative work plan

frequently impedes smooth exchange of data, information, and results, as already discussed in section 6.3.1. In addition, Globaqua partners are engaged in other professional activities, which makes a time management an issue to most of them, especially because not only they have to do scientific work, but also be responsible for coordinating the work of a work package, a Module, or even both. Having in mind that the second level integration is to start and intensify preliminary in 2016 autumn, a necessity for a more organised guidance from project coordinators in this respect has been emphasized by the project partners.

6.3.4. Clear tasks and goals

With regard to clearly knowing their tasks in Globaqua, partners have not identified any critical issues. Yet, as Globaqua is a highly intense project, having many activities not only stimulates collaboration, but also causes a great deal of bewilderment, when it comes to sharing the responsibilities for delivering the tasks: To illustrate:

> *"It sometimes happens that we know the tasks, but there is a bit of confusion to understand, who needs to do it, how, and how to collaborate in order to do it".*

Granted, a lack of managerial guidance in this respect has been observed, as well as in the case of a given time frame of Globaqua.

Meanwhile, the picture gets more obscure, when it comes to understanding the project goals. Interestingly, interviews data indicates that there are several perceptions among the project partners of what Globaqua aims at, and they mainly differ per Module, ranging from rather more concrete objectives, such as answering particular scientific questions to much more ambitious ones – to inform and even improve policies on the EU level. In all cases, it is evident that no one common project vision is dominant, so, a blurred understanding of the main objective of Globaqua prevails. Yet, the importance of clearly understanding the project goals has been highly acknowledged:

> *"If you are not aware of the main project ideas, and of this need for integration and its benefits, you surely not going to invest an extra effort of yours to deliver the results".*

With this in mind, the observation from the interviews allows generalizing that there is certain portion of scientists that prefer focusing on their disciplinary work, rather on projecting a whole Globaqua into the future. And that is an outcome of a simple, yet crucial reason – in the early stages of Globaqua, the main project ideas have not been made explicit to the partners.

To conclude, an extensive reflection on the overall organisational setting of Globaqua has revealed several important points that should be emphasized. First, overall logic of collaborative work plan does not always facilitate interdisciplinary collaboration among project partners. It rather poses administrative and scientific burdens in terms in writing too many articles, and going through the procedure of submitting them. It also causes time constraints, and finally, obstacles in gaining and/or exchanging data between different work packages or partners. Second, official project meetings, compared to informal collaboration among

participants, contribute less essentially to enhancing interdisciplinarity, according to the project partners. Instead, self-organised interactions and contact links foster and facilitate interdisciplinary collaboration to a much greater extent. Third, a clear guidance has been observed to be missing in terms of the overall strategy and the main objectives of Globaqua. It is, therefore, fairly to state that there is ample room for improving organisational arrangements in the second half of the project.

6.4. Collaborative team atmosphere and challenges in Globaqua

Given the discussion on the influencing factors and conditions, it is important to look at the collaborative team atmosphere and challenges present in Globaqua. Elaboration on them will substantially add to answering the second sub-question of this research. Elaboration on both variables will include both quantitative and qualitative data analysis results. Also, generalising remarks will be drawn, if common trends are observed to be emerging from both data sets.

6.4.1. Group atmosphere in Globaqua

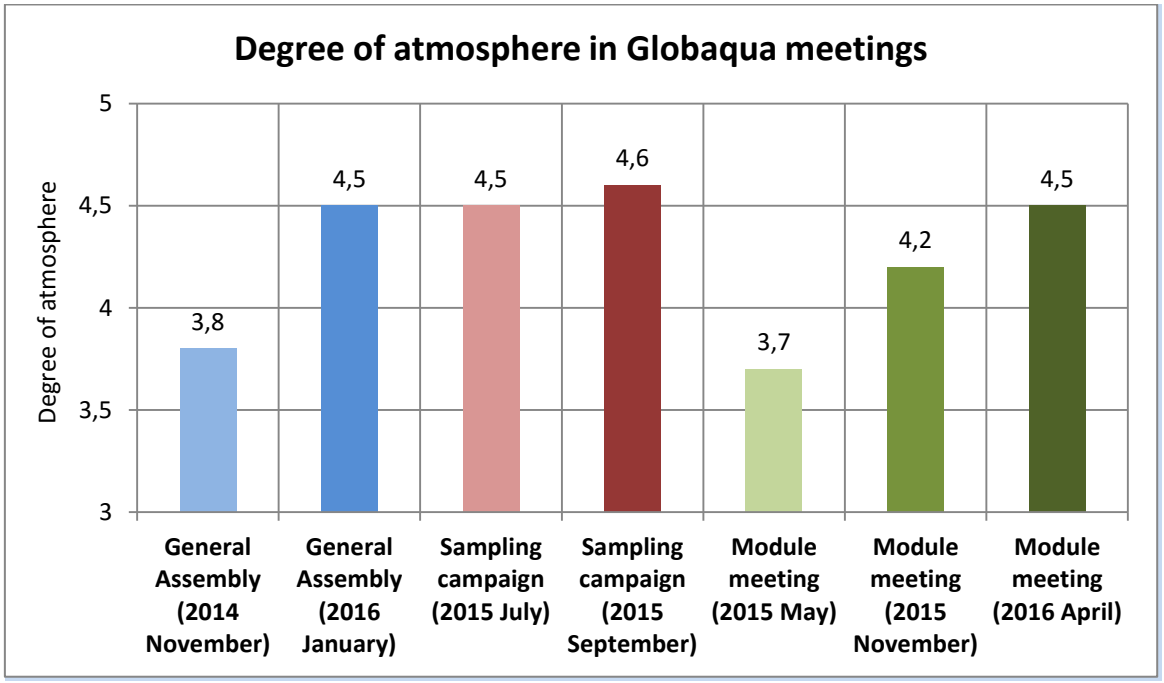
In Globaqua meetings

In all meetings, Globaqua participants have been asked to evaluate the atmosphere of a particular meeting. The collected data now allows comparing the results between the same and different type of meetings, as well as assessing, if a somewhat development in this respect can be observed.

First, if looking at the mean scores of how the respondents evaluated the atmosphere within the same type of meetings, the results are not uniform (see Figure 11 below). In the context of General Assemblies, the atmosphere was evaluated to a 'relatively high' degree in the first, and to a 'high' degree in the second meeting, amounting to 3.8 points on average and 4.5 points on average respectively. So, a considerable increase in the second meeting is observed in terms of the degree of the atmosphere. Then, when looking at the atmosphere in both Sampling campaigns, a slightly different picture appears: both meetings were evaluated to a 'high' degree of atmosphere (> 4.5 points on average). Finally, the mean scores on atmosphere in the three Module meetings amount to 3.7, 4.2, and 4.5 accordingly, and are of 'relatively high' and 'high' degrees. Essentially, the overall atmosphere has steadily grew along the timeline of all three Module meetings. For the sake of looking at the correlations between the atmosphere in different Globaqua meetings and interdisciplinarity dimensions, the statistical analysis results are provided in Appendix 5.

Second, if looking at the means on atmosphere in the meetings of a different type in parallel, considerable differences between the Sampling campaigns and the other two types of meetings – General Assemblies and Module meetings are exposed (see Figure 11).

Figure 11. Degree of atmosphere in Globaqua meetings



Source: Developed by the author, based on the statistical survey data analysis

It is no wonder that Sampling campaigns score the highest on atmosphere. They have been named by the project partners as the most informal, and the less structured, compared to the other official Globaqua meetings. Nonetheless, the means on atmosphere in the last General Assembly and Module meeting amount to 4.5 points, and nearly conform to the degree of atmosphere in the second Sampling campaign (4.6 points). Such results can be to some extent justified by invoking the answers to the open survey questions from both of these meetings. With regard to the last General Assembly, project partners evaluated it to 8.3 points on average, indicating it as “very productive”, and “well organised”, especially because “many (nearly all) partners were present”. In addition, almost uniform opinion prevails that “many problems were addressed and also partly solved” and that “good discussions” have been started”. Also, a large portion of the respondents reflected on highly positive atmosphere in this meeting. Speaking about the last Module meeting, again, positive evaluations dominate. The project partners acknowledged that “good advances in identifying topics for contributions”, and “decisions about common work” have been made in this meeting. “Perfect atmosphere” was also commended, and the meeting was overall evaluated by 8 points on average.

To sum up, the evaluations of the atmosphere in different Globaqua meetings indicate that no lower than a ‘relatively high’ degree has been discovered, indicating that the degree has increased, when comparing between the same type of meetings, and in some cases – even in a sharp manner.

Current overall atmosphere in the project

Assessing the overall atmosphere in the project is a less complex task. Having summarised the interviews data in this respect, the respondents' reflection on the overall atmosphere in Globaqua is "very much collaborative" and "highly positive". To say this is not to deny that there are various daily issues, misunderstandings, and disagreements on how to proceed in the project. Coupled with these inevitable work-related difficulties, some personal tensions also exist prevail:

> *"Despite that there is good overall atmosphere in the project, there are also some tensions between certain people that does not help very much."*

However, a significant majority of the respondents generally see the atmosphere more facilitating and collaborative, rather than somewhat problematic, or even unpleasant. The earlier discussed off-the-record collaborations taking place in Globaqua in parallel to the project work only support the claim of a positive atmosphere in the Consortium. Side activities otherwise would not seem to be possible, if uncomfortable working environment exists.

6.4.2. Challenges to interdisciplinary collaboration in Globaqua

Challenges in Globaqua meetings

The respondents also evaluated the degree, to which challenges came to the fore in the meetings. Survey data allows drawing some concluding remarks in this respect in the same fashion as in the previous section – between the same types, as well as between different types of Globaqua meetings.

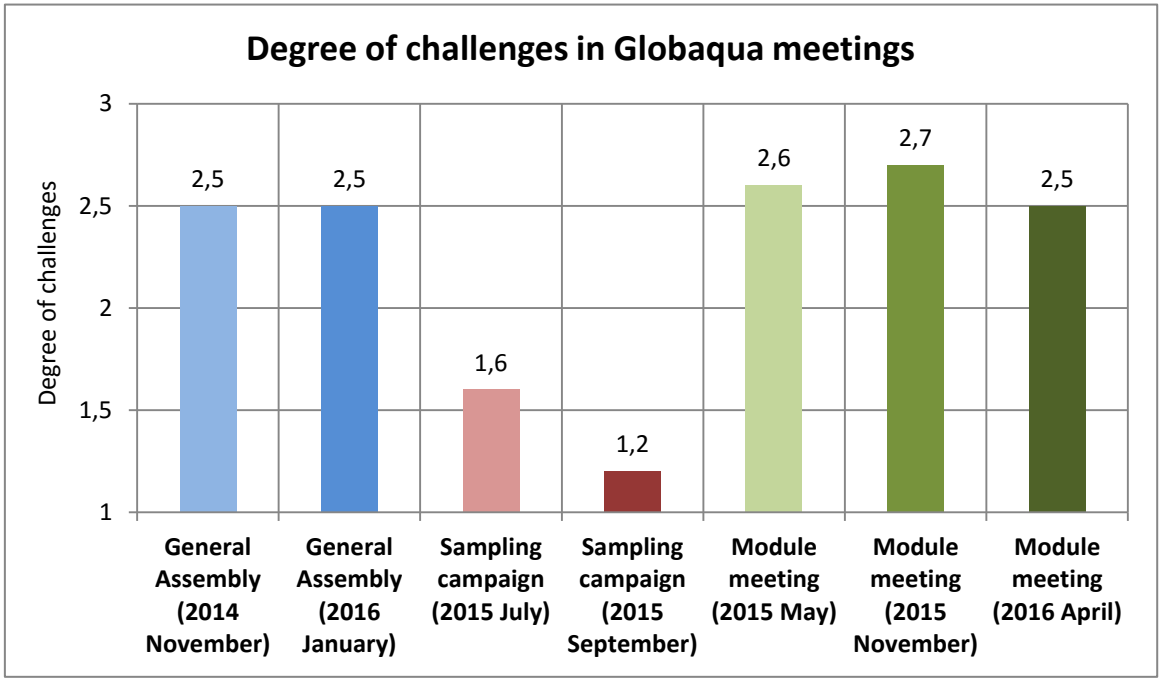
First, statistical data analysis has revealed considerable differences in the results within the same type of meetings. In both General Assemblies, the degree, to which challenges were evaluated as present, is 'moderate' of 2.5 points on average, although the score is just on the verge of 'relatively low'. The results from the Sampling campaigns show completely the opposite expression: not only the average score on challenges in both Sampling campaigns amount to a considerably lower degree, but also a decrease in the mean score is evident in the data from the second Sampling campaign. The mean scores on challenges are 1.6 and 1.2 points, and account to a 'relatively low' and a 'low' degree respectively. When looking at Module meetings in terms of challenges, the degree is 'moderate', with only little variation in the mean scores. Notably, data from the second Module meeting shows the highest score on challenges, implying that the respondents faced most difficulties in this meeting, if compared to other two meetings.

To note, the results of statistical survey analysis in terms of correlations between the challenges and the interdisciplinarity dimensions constructs are summarised in Appendix 6.

Second, if looking at a broader picture in terms of challenges present in different types of Globaqua meetings, Figure 12 below depicts the mean scores in parallel. Evidently, the respondents indicated being exposed to certain challenges to the lowest degree in both Sampling campaigns, whilst the presence of challenges in both General Assemblies and Module meetings is nearly the same. Further, with an exception of both Sampling campaigns, changes in mean scores were very minor, meanwhile, the degree of challenges present

in the second Sampling campaign decreased considerably to a 'low' degree, based on the respondents' evaluations. Such results may be primarily associated with the highest scores on the atmosphere in both Sampling campaigns, and the answers to the open survey questions from both Sampling campaigns seem to support this statement.

Figure 12. Degree of challenges in Globaqua meetings



Source: Developed by the author, based on the statistical survey data analysis

To sum up, if looking at all Globaqua meetings, the overall tendency is that the degree of challenges, to which project partners were exposed to in certain types of meetings, remained the same, or marginally decreased. Only the results from the second Module meeting show an exception, indicating a very minor increase in the mean score on challenges in that particular meeting.

Most significant challenges in Globaqua

Disciplinary language

The first and most substantial challenge in Globaqua is disciplinary language. Having in mind that Globaqua partners come from different cultures, have different expertise, and speak different languages, they make a compromise to speak in English, when it comes to collaboration with others. They naturally think that this is what they need in order to understand each other, which eventually appears not to be sufficient because fundamental differences in disciplinary languages still remain. As a result, they become apparent in two ways. First, these differences relate to an organisational part of collaboration – a process of what, how, and when is to be done by the project partners for proceeding with individual and collaborative tasks and deliverables:

"The difficulties we had were related to understanding, what other people from different work packages they do, what they want from others, and what they can offer other partners".

Without having a concrete agreement on the questions above, it is unrealistic to expect fruitful collaboration to develop, project partners say. Also, it takes time to realize that you do not really understand each other, what incurs additional difficulties: unmet schedules and tasks, lost interest in the project, and frustration in a long-term. Building upon this, the second aspect of disciplinary language barrier relates to a more content part of interdisciplinary collaboration, and implies that misunderstandings in terms of concepts used by different languages in Globaqua are present:

"The same problem may be defined differently by the physicists, by the biologists, and by the economists. But, at the end of the day, they were all referring to the same problem".

To illustrate, an example given by one of the interviewees can be invoked: in Globaqua, the main tension with regard to a scientific misunderstanding between scientists is two-fold. First, the tension prevails between the blocks of Natural and Social Sciences, where both domains question each other's scientific capability to solve certain problems. Second, the tension exists also between the natural scientists and the modellers, as the latter use their own data, approach to process it, and language in explaining their results. Both tensions, as a matter of fact, arise from inherent differences in disciplinary languages, which cannot be overcome overnight, but rather gradually.

To sum up, with regard to both aspects of this challenge, it is important to note that, whilst the first one tends to continuously prevail during the whole life-course of the project, the latter aspect is particularly inherent to the early stages of the project, as scientists are simply not aware of the extent, to which their disciplinary approach differs from the one of others. With no surprise hence this challenge has been named by the project partners as the most significant in Globaqua, where a wide range of collaborative tasks require a profound mutual understanding in the first place.

Not having one common thing to achieve

It is no surprise that Globaqua, being a five-year large scale project, has a wide range of different objectives en route to achieving its main goal. The associated risk associated, however, is that concentrating on day-to-day tasks may make project partners neglect the core objective of Globaqua. Thus, not a few interviewees mentioned the issue of not having a common project vision:

"We are not having that one particular thing that we are developing together".

Moreover, an insight has been shared during the interviews with regard to the main goal of Globaqua, stating that it is simply not mandatory, or in other words, was not explicitly made as such in the very beginning of the project. And this statement bears crucial importance: as the main project goals, as well as a common strategy for achieving these had not been clearly formulated in the early stages of Globaqua, uncertainties with the course of the project prevail, accompanied with partners' reluctance to invest more of their

resources in pursuing the project's objectives. This statement is, in fact, based on the overall observation during the interviews with project partners:

> *"Only because it [the project goal – J. S.] is not mandatory, people are afraid of investing in unknown or uncertain benefits. <…> They prefer not to invest time into something they do not know, whether will produce positive outcome, or not".*

Lack of seeing the real value of other's work

One more challenge is uneven value, assigned to the work by the project partners. To clarify:

> *"To some extent, there is a lack of appreciation of the other partners' value in the project".*

A strong connection between this challenge and people's disciplinary background can be observed:

> *"Naturalists often think Social Sciences is something just for fun, or not good enough in solving certain issues, for instance, in a relation to river basin management".*

Another aspect of this challenge is related to oversimplification of other disciplines (and/or work packages) in terms of their work. It has been observed from the interviews that different disciplines (un)consciously tend to treat other disciplines as doing science in an ordinary way. As such:

> *"What happens sometimes is that people from Ecology or Social Sciences, for instance, consider a hydrological model as something that can be done quite easily, or in a standard way, but in many cases this is not the case. And vice versa – being a hydrologist, the main risk is not to fully consider the complexity and the difficulties of other disciplines."*

To contrast, the opposite situation, can also happen, meaning that certain disciplines tend to overestimate their own capacity in addressing certain scientific questions, and consequently, undermine the added value of collaboration with other disciplines in achieving tasks.

Adaptation to each other's schedule

A difficulty to conform to the schedules of others has been also identified by some of the interviewees as a burden at certain moments in Globaqua, as a result of organisational setting:

> *"Modellers want us to provide them with information on what scenarios they have to model. But these scenarios arrive to us only after we have some data from our first experiments. <…> Everybody would like to have the information pieces they need by day one of the project, but they do not arrive that soon".*

Granted, Globaqua scientists are often exposed to a time burden due to the fact that in order to accomplish some of their tasks in the project they need an input from other partners. And such an interdependent organisation of work yet sometimes results in an impasse.

Integration of all the activities in the project

Lastly, the second level integration in Globaqua, is to be become one of the biggest challenges:

> *"The major challenge is to build a sort of a synthesis of all the activities that are going on in Globaqua. We have a lot of activities, they all are all very interesting <…>, but at the end, we need to provide a synthesis, which is quite difficult".*

To touch upon this challenge is not to state that Globaqua is already exposed to it. Instead, it is something to be cautious of, when the project level integration will start in the upcoming months.

To summarise, discussing the challenges of a different type that the project partners addressed during the interviews has revealed diverse insights on the further explanation of a progress of interdisciplinarity in Globaqua to be provided in Chapter 7. In addition, an extensive elaboration on these challenges has also served to note the aspects, which might be improved in the later stages of the project. Yet, according to the project partners, the degree, to which Globaqua is seriously exposed to certain challenges at the moment is rather low.

6.5. Management strategies in Globaqua

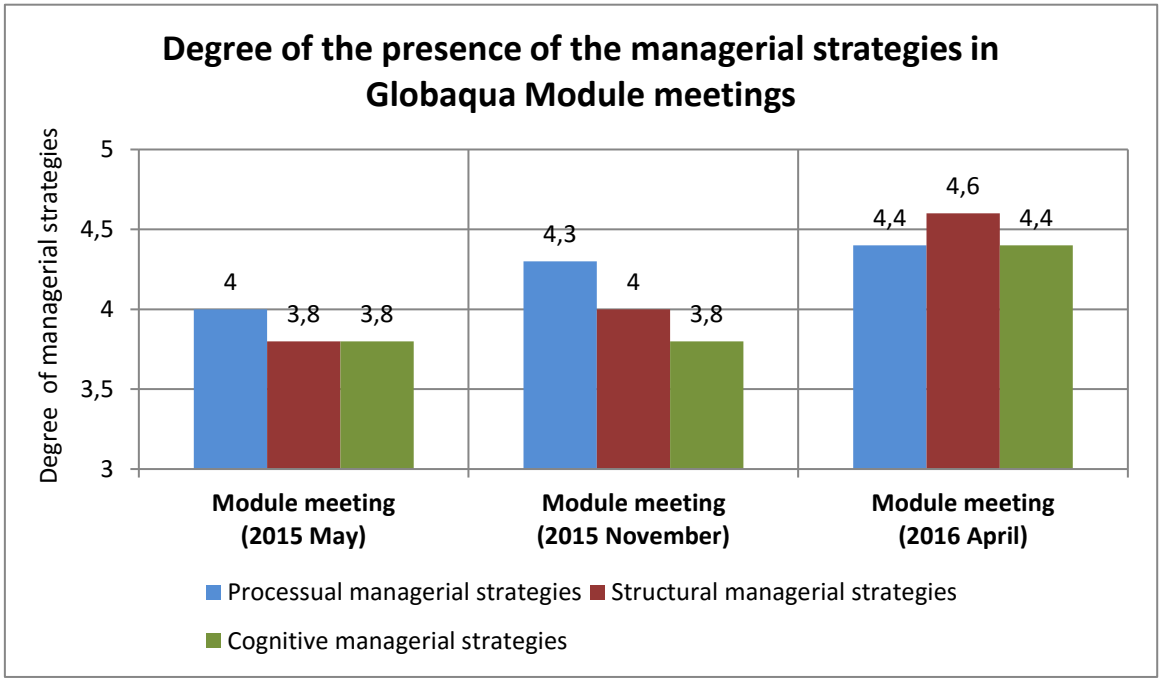
Moving further with an investigation of the determinants to interdisciplinarity collaboration, this section will address the fourth cluster of factors in this research – management strategies of three different types. The intention is hence two-fold: first, to see which managerial strategies are present in the project, and second, how in particular they influence interdisciplinary collaboration, according to the project partners. The discussion on management strategies will include elaboration on both quantitative and qualitative data results, providing distinct insights on the management of Globaqua Module meetings, and on the assessment of the management strategies on the overall project level.

6.5.1. Management of Globaqua Module meetings

First of all, a closer look is to be taken at each of the managerial strategies in all three Module meetings. If looking at the processual management of the Module meetings, it was evaluated to a 'relatively high' degree in the first meeting, and the mean score gradually grew across the second and the third meetings. Granted, the results suggest that processual management has been present in all three Module meetings to a 'relatively high' degree, according to the survey respondents. The results on the structural management of Module meetings show a fairly similar expression in terms of the mean score, given by the survey respondents. In the first meeting, structural strategies were present up to a 'relatively high' degree, and have grown steadily in the other two meetings, hitting a 'high' degree of 4.6 points on average recently in 2016 April. Finally, the same tendency in the mean scores on cognitive management in all three Module meetings is evident. In the first two meetings, the degree was evaluated to a 'relatively high' degree, whilst in the last Module meeting, the mean score increased markedly, although the degree remained the same.

Second of all, if juxtaposing the mean scores on all three managerial dimensions between the three Module meetings, Figure 13 below enables some generalisations of a different focus.

Figure 13. Degree of the presence of the managerial strategies in Globaqua Module meetings



Source: Developed by the author, based on the statistical survey data analysis

Evidently, the highest scores on all three types of managerial strategies are observed in the third Module meeting, which was assessed as of a "perfect organisation", "constructive", and "effective in setting deadlines and coordinating data transfer" by the respondents, when answering the open survey questions. In contrast, a somewhat lowest scores were assigned to the management strategies in the first Module meeting. Invoking some of the open questions answers from the survey of that meeting to some extent justifies these scores. The project partners reflected on the first Module meeting as "an update meeting mainly", in which "information needs to be presented more clearly and concisely". To add, the respondents indicated that "still, too much discussions, <…> and less progress" was made at a time, and thus, "better organization is needed from coordination". Notably, statistical correlation test results on relationships between three types of management strategies and interdisciplinarity dimensions, atmosphere, and challenges are provided in Appendix 7.

To sum up, when assessing the presence of three different types of managerial strategies in Globaqua Module meetings, to a great sudden, the evolutionary progress along the three meetings is observed in terms of all three strategies. Although the cognitive management strategies seem to demonstrate a somewhat lower degree in all meetings, no one managerial strategy, however, can be conclusively assessed as the most, or the least developed in the Module meetings because the degrees of their presence vary in a similar fashion per all three meetings.

6.5.2. Managerial strategies present overall in Globaqua

Having processed the interviews data, some findings can be outlined as well, when speaking about all three types of managerial strategies observed overall in the project. That is no surprise that all management types at some cases become more evident. The difference is, however, in which ones are employed by the Module or work package leaders, and which ones by the Management Team.

Regarding the processual management, it is has been the most extensively discussed strategy during the interviews. Both Module and work package leaders undertake various actions for managing the process of their group work, as well as of their collaboration with others. They do that, for instance, by arranging small meetings for the groups in order to stimulate interaction between different disciplines, when needed. Also, for expressing expectations, doubts, and needs so as to facilitate the better atmosphere for common work. Not only the leaders organise such meetings, but they also participate in them, willing to ensure that all the involved parties are respected, and have a say there. Moreover, an important aspect of process management has been brought up by several respondents in relation to incentives to be given to Globaqua participants, such as "prospects of continuation, publications, speeches in high-profile events", and other. They are important in order to get a return from Globaqua scientists – their time and efforts, invested in the project. And this is something that some of the Module leaders do, according to the respondents. Furthermore, another nice example of process management has been shared by one Module leader: the idea to start organising Module leader meetings for having a more organised and structured plan for an inter-collaboration of particular Modules and work packages within the project. The necessity for this is caused by the fact that there is no common vision on how to proceed in Globaqua with an integration of scientific results on the project level. A novel initiative hence has been recently started to make the coordination smoother and more purposeful by the Module leaders.

Speaking about the structural management in Globaqua, interview respondents shared fewer, but quite some examples with regard to it as well. For instance, structural strategies become more apparent, when an important meeting is upcoming, or the deliverables are on the horizon. Then, either work package or Module leaders often take a role in intensifying interaction between certain work packages or people, and stimulating information exchange among participants. In addition, regardless to the specific tasks to be accomplished, it has been noted that project leaders often take care of organisation of work in terms of connecting different units within the project by themselves. Lastly, some of the respondents have reflected on the role of the project management in Globaqua:

> "The project management has a focus more on the organisation of this complex machine".

When it comes to the cognitive management strategies, although a discussion is not that extensive, the importance of knowledge management by the project partners has been yet acknowledged. When asked about their role as either Module, or work packages leaders in Globaqua, the respondents mainly invoked an example of helping their counterparts understand the main tasks and objectives of the project. To illustrate:

> *"What we did in these years is to translate the description of work of Globaqua into a real work plan".*

By doing that, they are fulfilling their responsibility to foster deeper understanding of the connection between different disciplines for one crucial reason:

"If people understand, what is going, they are willing to participate in a challenging task".

And vice versa – if project partners do not seem to clearly understand their tasks, they eventually become resistant, as it was said. So, it is in both Module and work package leaders hands not to let anyone fall behind the group in terms of understanding, knowledge, and capacity.

To conclude, having reviewed the interviews data, it might be stated that the Management Team undertakes mostly the structural management strategies, whilst the other two – processual and cognitive strategies are more undertaken by Module and/or work package leaders on a group level.

6.6. Reflection on interdisciplinary collaboration part of the model

By combining both quantitative and qualitative data sets, Chapter 6 has thus far provided a very detailed discussion on the interdisciplinary collaboration part of the conceptual model. Building upon it further, the overall reflection on it is to be provided, by first, reviewing collaborative team learning behaviour among the project partners, and second, by delineating the summary of factors of a high importance to this process.

6.6.2. Combining the results: collaborative Globaqua team learning behaviour

In the conceptual model, it has been presupposed that Globaqua researchers are to undergo an evolutionary team collaboration path from collaborative efforts to collaborative capacity to interdisciplinary collaboration stages. The actual picture, apparent as a result of the reflections of the project partners, implies a somewhat non-linear team learning development in Globaqua.

To clarify, the first *collaborative efforts* stage is the most obvious, when reflecting on the atmosphere and challenges that project partners have been, and are still exposed to. A progress from more official and matter-of-fact atmosphere in the Consortium, the interview respondents expressed it being developed to a more professional and in some cases closely personal working environment, enhancing the collaborative work in Consortium, which currently is highly "pleasant" and "comfortable". In addition, a statistical analysis of the data confirms this evolutionary aspect of the overall atmosphere in Globaqua: a steady increase in the mean scores on this construct is evident, comparing between the same types of meetings (see section 6.4.1.). When looking at the overall degree of challenges present, an evolutionary aspect in this respect has also been captured in both analyses. The interviewees shared their experience of dealing with disciplinary language, and uncertainty in tasks and goals challenges to a greater extent than now in the middle of the project. Currently, not having one common thing (a 'boundary object'), as well as acknowledging the uncertainties in relation to the second level integration have been raised as more prevalent challenges. In addition, similarly as in the case of the mean scores on atmosphere in Globaqua meetings, statistical analysis shows the degree of challenges in different types of meetings either remaining the same, or slightly decreasing over time.

Speaking about the second stage – *collaborative capacity,* it can be fairly stated that the remarks, made by some of the project partners, show this stage being advanced. As a matter of fact, the respondents admitted that on a group level, trust among participants exists. It has been acknowledged as developing not only in relation to a more informal work environment, but also in terms of trusting each other's scientific work and inputs in the project over time. In addition, off-side collaboration examples, given in 6.3.2., imply certain level of trust prevailing among a portion of Globaqua partners. Moreover, no counterarguments have been observed in relation to constructive conflict among project partners. Nonetheless, a generalising remark that the stage of collaborative capacity is fully developed on the overall project level as well cannot be made because the overall assessment made by the researcher leaves some doubts in this respect.

Finally, getting back to the remark mentioned above of non-linear process of team learning, it has been observed that *interdisciplinary collaboration* stage rather than being an end-stage, develops alongside the other two stages. In addition, all three collaborative team learning stages are developing throughout the whole life-course of the project. This finding, thus, conforms to the conclusion in the case of the development of interdisciplinarity dimensions, drawn in Chapter 5.

6.6.2. Summarising the determinants to interdisciplinary collaboration

First, factors of a professional type exert the highest importance, when interdisciplinary collaboration is to take place. Not only the disciplinary diversity enables collaborative research, but it also makes it complex in terms of achieving consensus on which scientific tools are to be applied in addressing a given topic.

Second, two particular aspects of the overall organisational design of Globaqua have been acknowledged as one of the most influencing factors to interdisciplinarity in Globaqua. One, the project partners stressed the burden posed by the tasks and deliverables, pre-sent in the DoW, and raised the need to re-write the DoW. It has been noted that it is hardly possible to be aware of the actual relationship needed in the project as this becomes clear only during the process of collaboration. The pre-set work plan, as a matter of fact, unfolded in practice not fully in accordance to what has been initially planned due to a relational basis: some Globaqua partners are more willing to do certain tasks, are more available or devote more time than the others. Yet, the initial design of collaborative tasks and deliverables to some extent causes a somewhat inefficient way of working, and lack of time in delivering certain responsibilities. Considered as one of the limitations of the project design, this puts a burden specifically on interactive research, which requires a lot of interaction between different disciplines, during which research methods, theories, and models of different academic perspectives are to integrate in between. As the DoW can be re-written only during General Assemblies once a year, it limits a full potential of the project in terms of the productivity of interdisciplinary interactions, several Module leaders said. Globaqua yet demonstrates a relatively solid presence of self-organisation on a group level in this respect: when additional interaction between certain units in the project is needed for accomplishing project tasks, Module leaders engage in connecting people from different work packages and Modules, "enabling information and knowledge exchange", as well as broadening the extent, to which

interactive research in Globaqua flourishes. As a result, the pre-set collaborative work plan currently shows more dense interaction between the different project units than initially set (see section 5.3.2.).

Clear project goals have been named as another aspect of organisational factors of a paramount importance to interdisciplinarity. The observation suggests that attempts to make the project objective explicit in the beginning of the project have not been put by the Management Team. Moreover, some project partners expressed their concern that the idea of a 'market place' has not been picked up by the Management Team early in the project, which would have somewhat changed the situation in this respect. Yet, currently, an associated problem that the overall strategy of integration in Globaqua is missing prevails, and to some extent discourages researchers invest only as much of their resources as they actually need for fulfilling their tasks. As a result, it seems that a certain degree of commitment among project partners is present. It is limited, however, to mostly accomplishing their own tasks, and does not foster reaching project goals because they are simply vague. In this respect, the observation to be made is that the Management Team has not taken an effort to bind all project partners in achieving a common goal from the kick-off meeting onward. Instead, the project coordination is mostly engaged in *structural management,* to ensure that no administrative burdens come to the fore when implementing the DoW, and that the project deadlines are met. Consequently, gaps in processual and cognitive management on the overall project level significantly affect the advancement of knowledge integration, and integrative understanding, and the way researchers interact with each other in Globaqua, the respondents said.

Third, two types of management strategies – processual and cognitive strategies appear to be of a high importance in Globaqua, although they are not fully developed on the overall project level, if looking at the interviews. With regard to the former strategy, the way the project is being managed has been brought to the fore by a significant majority of the project partners, and closely relates to the above discussion on the organisational setting in the project. The interviews revealed a prevailing opinion that process guidance in Globaqua in most cases is undertaken by Module leaders on a group level. Further, speaking about knowledge management – the cognitive strategy, it has been acknowledged by the project partners as important as the previous strategy. Similarly, it is not being undertaken by the Management Team in the project, but rather by single work package and Module leaders in translating the DoW into a real work plan, and especially in addressing the need of and showing the opportunities for knowledge integration among different disciplines that is crucial for advancing integrative understanding and effectiveness in advancing understanding dimensions of interdisciplinarity. Overall, the potential these two managerial strategies have in enhancing interdisciplinary collaboration is highly acknowledged in the project. Yet, as they are undertaken only on a group level, certain gaps in interdisciplinary collaboration on the overall project level remain.

Chapter VII: Capturing the evolution of scientific knowledge integration in Globaqua

The last step in this research is to be made in order to sharpen the extensive discussions on the degree of interdisciplinarity, as well as on the factors and conditions so as to take the analysis to the final stage. For this purpose, a concise summary of the factors, bearing an explanatory power to a progress of scientific knowledge integration is to be provided. With this in mind, the last research sub-question is to be answered:

- How can the evolution of interdisciplinarity in Globaqua be explained?

In addition, certain findings of a paramount importance will be drawn in relation to 'integration': a distinction between the two levels of integration will be consolidated, and coupled with an observation of the overall picture of the implementation of the collaborative work plan in the project.

7.1. Explaining a progress of interdisciplinarity in Globaqua

It has been concluded in Chapter 5 that the current degree, to which scientific knowledge integration has been achieved thus far in Globaqua, is 'relatively high', if both quantitative and qualitative data results are combined. Also, attempts have been made in that chapter to indicatively explain, why interdisciplinarity was evaluated higher in one type of meetings, or why the scores on certain interdisciplinarity dimensions differ per meetings of a different type. Yet, as the quantitative and qualitative data sets are not fully comparable due to the fact that the survey data refers to assessing interdisciplinarity in different types of Globaqua meetings, whilst the interview data investigates the overall degree of scientific knowledge integration in the project, it is complicated to conclusively state, why a certain degree of interdisciplinarity has been achieved in the project up to date. In fact, the degree of interdisciplinarity was quite high in the very first Globaqua meeting, in which data on monitoring scientific knowledge integration was collected for the first time. The reason is likely to be a combination of a variety of factors – different perceptions of interdisciplinarity (as showed in section 5.1.), high positive expectations of the potential of the project in the very beginning, and other. Yet, explaining the reasons of that is simply out of a scientific interest of this research.

Instead, it has been discovered in the present study that the level of scientific knowledge integration is progressing between the same type meetings, and this finding necessitates a profound explanation. In order to come up with an explanatory picture of factors and conditions, supporting this progress, it is essential to invoke the distinction between the two levels – the group, and the project level. This distinction, in fact, conforms to the two different types of integration, already made this analysis as a result of the interviews. Whilst the latter will be extensively addressed in the next section, the focus, when explaining interdisciplinarity progress, is exceptionally on a group level, or the so-called first level of integration.

The first level integration refers to the scientific knowledge and practices integration between different disciplines, as already defined in section 5.2.2. It refers to a preliminary open-ended research phase, during which, according to Tait and Lyall (2007), researchers involved in an IDR project try out a range of possible boundaries to the problem, or a specific task in order to assess, which provides the best 'fit'. If looking

particularly at Globaqua, during the first half of the project, partners have been undergoing this phase of research, by searching for and establishing the links with each other in order to proceed with project tasks and deliverables, and so they (un)consciously engaged in interdisciplinary collaboration. As a result, integration of scientific knowledge and practices have resulted to a certain degree, as the survey results show, and has been observed on a group level, when interviewing project partners. To note, this phase of research does not require specific planning or guidance – collaborative efforts of scientists enable finding the most appropriate way of delivering certain tasks in the project. As such, collaborative team-work on a group level in Globaqua reveals the main reasons, explaining a progressing degree of interdisciplinarity.

First, it has been discovered that a large portion of Globaqua Consortium partners have a (long) common professional history, dating to the projects in the past – the main two are 'Climb' and 'Aquaterra'. The fact that the basic block of researchers, currently participating in Globaqua, have positive working experience with each other, has been discovered to be a highly facilitating condition for enhancing interdisciplinarity in the project. Not only it has been acknowledged by the project partners as such, but its effect is also evident, when it comes to understanding each other, as well as aligning working and disciplinary practices of different partners. Therefore, a smooth progress of interdisciplinarity in Globaqua, when assessing the group collaboration, is seen to be primarily influenced by the circumstance that a large number of project partners already know each other from previous professional endeavours.

Second, interactions between scientists in the project, as theory says, are directly enhanced by the positive atmosphere in the group. As such, Globaqua partners have uniformly reflected on the overall atmosphere as highly positive and facilitating collaboration with each other. Statistical data analysis shows a very similar expression: the overall atmosphere in all project meetings of different types, analysed in this study, was evaluated as 'relatively high' and 'high'. The degree of atmosphere has been steadily increasing between the same types of meetings, implying that not only a group, but also the overall project atmosphere is growing. As a result, a progress of interdisciplinarity can also be justified by the evolutionary process of improving atmosphere in Globaqua.

Third, in close relation to the previous condition, the trend of challenges, present in the project, also explains the gradual growth of interdisciplinarity in Globaqua. It is no secret that the project partners have indicated a range of challenges, to which Globaqua has been exposed to thus far (see section 6.4.2.). Nonetheless, having identified these is not to say that the current presence of challenges in the project is substantial. Conversely, when reflecting on the obstacles faced during the collaboration with each other, project partners admitted that no crucial barriers are yet hindering interactions, or joint work in the project on a group level. Only some deficiencies in guidance by the Management Team exist, coupled with certain administrative and organisational burdens. This finding conforms to the findings from the quantitative data analysis: the degree of challenges in different type of project meetings either remained the same, or decreased, implying that over the life-course of the project, a certain level of challenges to be tackled exists, but does not increase, and rather keeps decreasing over time. This tendency, observed from both data sets, thus, suggests additional explanation, why the overall degree of interdisciplinarity in Globaqua is increasing.

Fourth, the most evident explanatory factor discovered in this research is a high level of self-organisation among project partners, observed on a group level. Having acknowledged the lack of processual and cognitive steering from the project management, Globaqua partners revealed having a dense map of interactions between different work packages and even single partners or scientists that allows them overcoming a range of organisational and administrative obstacles, or understanding issues. As such, self-organised collaboration, coupled with processual and cognitive managerial strategies undertaken either by Module or work package leaders, compensates the management gaps on a group level, left by the Management Team. The latter is rather engaged in structural project management, which has not been acknowledged by the project partners as influencing interdisciplinarity in the project to a great deal. The concluding remark hence can be made that the observed self-organising capacity of Globaqua partners substantially enhances the progress of scientific knowledge and practice integration in the project.

In addition to the above explanatory factors, two types of supporting factors should also be noted, when interpreting a progress of interdisciplinarity in Globaqua. First, although individual cluster of factors has not been addressed as exerting crucial influence to interdisciplinarity in Globaqua, the facilitating effect the individual factors, such as willingness, flexibility, open-mindedness, and having genuine interest in the project, has been largely observed, and, as a result, partly adding to the explanation of a progress of scientific knowledge integration in the project. Second, one factor from the professional cluster is also evident as contributing to the overall explanation of the interdisciplinarity progress. In particular, having previous experience in IDR projects serves as a factor, somewhat contributing to the advancement of interdisciplinarity as well because the Globaqua Consortium seems to have been relatively experienced in IDR, prior joining Globaqua, as the statistical data results have showed.

Taking all the above into consideration, the evolutionary progress of interdisciplinarity in Globaqua has been found to be conditioned by the four principal factors: knowing each other from the previous professional endeavours, strongly positive atmosphere in the Consortium, relatively low presence of challenges in the project, and a high level of self-organisation of the project partners on a group level. Further, having a genuine interest in the topic, being an inviting and open-minded personality, and having experience in IDR projects altogether serve as facilitating conditions. Nevertheless, if aiming to expand this discussion to the overall project level, a focus of the discussion changes substantially: second level integration comes to the fore, and needs separate elaboration.

7.2. Second level integration in Globaqua: associated items and risks

Building further upon the previous section, discussion on the project level, or the second level integration differs fundamentally. What has been going on so far in Globaqua – open-ended integration of scientific knowledge and practices, as well as the emergence of shared understanding, concepts, and frameworks – was related to the first level integration, just discussed above. Meantime, an insight that the next stage of integration is approaching in Globaqua has been brought up by a large portion of project partners:

"The big challenge will start from now on – we will be trying to integrate all the results together."

The ‘new’ stage implies that the process of purposeful and coordinated integration of all the scientific results and inputs produced so far in Globaqua into coherent solutions and/or tools is to start in the upcoming months in 2016 fall. This transition from one to another stage of the project was noted by one Module leader:

> *“We have progressed a lot in the upper part of the collaborative work plan scheme. Now, the challenge is the bottom part of the collaborative scheme: how to translate these results to the European level”.*

According to Lyall and Tait (2007), unlike in the case of a preliminary research phase, the second level integration necessitates “an active strategy”: how exactly it is to be implemented. And this has been acknowledged as one of the biggest challenges soon to appear in Globaqua because, according to the project partners, there is no common strategy of how to combine and integrate both ongoing activities and scientific results into a synthesis in order to propose policy recommendations for managing the system approach to river basin management, required in the WFD. In other words, the question, in what shape or guise it will unfold, remains open, and leaves the project partners in an uncertainty of how their own results, and the results of their counterparts will eventually be combined. There is a consensus yet among only a small portion of Module and work package leaders on how this synthesis should look like in the end:

> *“In terms of knowledge. Knowledge of the effect of water stressors. The project is aiming to provide results that can be used by the Commission to develop new policies for the combined action of stressors”.*

Yet, there is no uniform opinion on how to achieve it, and whether the links will be established between the scientific results and policy recommendations.

As a result of the missing vision in the project, partners identified the gap between a somewhat more Natural Sciences part of the collaborative work scheme (Modules 1, 2, and 3), and a somewhat more Social Sciences part of the scheme (Modules 3 and 4) being rather deep (see Figure 10). Another noted reason was ill connection between the case studies and the overall project (or the respective Modules and work packages). Coupled with these reasons, the respondents expressed a concern with the absence of agreement between some partners in terms of specific experiments, collection of data, or of a particular way of working in the project, which is essential in order to align the different scales of disciplines. If more guidance was provided by the project management, case studies would had been simply more tailor-made, the interviewees said.

Logically, a rhetoric question arises: if the self-organising capacity on a group level successfully enhanced interdisciplinarity in Globaqua, would the same way of working be sufficient to ensure the transfer of scientific results to the EU policy level? Not as much as it is important to answer this question, but to say that, when it comes to the second level integration, active purposeful project management strategy is necessary. And that is where the challenge of no common strategy of integration in the project missing comes to the fore again. With this in mind, it is essential to investigate the process of project level integration in the further stage of the project so as to enable evaluating its associated items, risks, and outcome, at the end. It should be noted that a new way of capturing and assessing the second level integration needs to be developed to enable further research of the Globaqua case. As the results of this research show, the four interdisciplinarity dimensions neglect (or simply do not cover) the project level integration – only having employed the qualitative research method, the distinction between the two levels has been discovered.

Chapter VIII: Conclusions and recommendations

In this study, the main research question has been raised:

> *How the evolution of scientific knowledge integration can be measured, and which factors hold an influence on the progress of interdisciplinary collaboration in Globaqua?*

Having provided an extensive empirical analysis, aimed at conclusively answering this questions, the last chapter of this study will, first, present the conclusions on the evaluation of scientific knowledge integration in Globaqua, and second, introduce the respective recommendations. In the former case, conclusions will summarise a two-fold focus of this research: detailing how to measure interdisciplinarity progress, and reflecting on interdisciplinary collaboration in terms of explanatory factors and conditions. In the former case, recommendations as a result of an in-depth case study are to be provided in terms of scientific measurement of the evolution of interdisciplinarity, and of the overall planning and design of large scale interdisciplinary projects in the future, based on the findings of this study.

8.1. Measuring and explaining a progress of interdisciplinarity

The main research question of how to measure the evolution of scientific knowledge integration, and what factors influence the process of interdisciplinary collaboration in Globaqua has been set in this study. For this purpose, a deliberate distinction between the concepts of interdisciplinarity and interdisciplinary collaboration has been made. The former relates more to a content aspect of scientific knowledge integration, and refers to a synthesis of disciplinary knowledge and practices in terms of research methods, theories, and models, through which an advanced understanding and new knowledge develops. Accordingly, a four-dimensional progress framework of interdisciplinarity has been introduced in the theoretical framework. Meanwhile, the latter reflects a more process component of scientific knowledge integration, and has been defined in this research as a relational interaction among researchers, undergoing three collaborative team learning phases: collaborative efforts, collaborative capacity, and interdisciplinary collaboration, to name these.

Altogether, the theoretical framework in this study is grounded in two vast perspectives – interdisciplinary discourse and collaboration approach to interdisciplinary research that have been summarised in the two-fold conceptual model. This model served as a guidance for the empirical part of this research, presupposing four types of factors and conditions, influencing this process of scientific knowledge integration. By employing a triangulation of quantitative and qualitative methods, an in-depth case study of the Globaqua project has been carried out: the survey questionnaires have been used in monitoring the degree of interdisciplinarity in three different types of Globaqua meetings along the timeline of the project, whilst the interviews served in assessing the overall level of interdisciplinarity achieved so far in the project up to 2016 June, as well as the associated items and concerns of this progress. Notably, both methods covered some of the constituent variables in the conceptual model, and, therefore, made the process of combining and

comparing the results from both data sets more complex than initially expected. Large amount of quantitative and qualitative data has been collected, processed, and discussed in Chapters 5, 6, and 7. As a result, the core conclusions are to be presented in relation to this in the next paragraph.

First, with regard to measuring the evolution of interdisciplinarity, in this research, a satisfactory framework of reliable constructs of variables has been applied and tested statistically. In addition, a methodological choice has been made in this research to enhance the measurement of interdisciplinarity process by investigating the socio-cognitive processes behind interdisciplinary collaboration. For this purpose, a wide range of factors and conditions of various types have been included in the conceptual model of this study that has been used as an open-ended guide for explaining the finding of this research – the evolution of interdisciplinarity in Globaqua, discovered having combined both quantitative and qualitative data results. Moreover, it has been found that a progress of the dimensions in Globaqua does not follow a sequential path, but rather demonstrates takes place on all three dimensions – *interactive research, integrative understanding, and effectiveness in advancing understanding* – simultaneously. As such, the overall interdisciplinarity in Globaqua currently is of a different degree on each dimension, and shows a room for a sound improvement in the second half of the project.

Second, the evolutionary aspect of scientific knowledge integration has also revealed two different levels of integration in the project. The first one refers to a more (un)conscious or natural scientific knowledge and practices integration, which does not require any specific strategy to be implemented. It is a rather preliminary research phase of an open-ended nature. Globaqua has been found to be undergoing under this process, which is also referred to in this study as the first level integration. Meanwhile, another phase to follow in turn is the so-called second level integration of all the scientific results in the project thus far. As such, it requires an active strategy undertaken by the Management Team of Globaqua for achieving the synthesis of inputs, and transferring the integrated solutions to river basins management to the EU level. Nevertheless, the latter is yet to start, and a clear vision or a strategy of how it is going to be implemented in Globaqua is yet missing.

Third, four different clusters of factors and conditions have been investigated in this study in relation to interdisciplinary collaboration. Having carefully processed both quantitative and qualitative data analyses, a two-fold reflection on the results should be made. First, certain factors have been discovered in the context of Globaqua as important to interdisciplinary collaboration. These are the professional factor – disciplinary background, structural and organisational conditions, such as pre-set logic collaborative work plan, and explicit project goals on the overall project level, as well as management tasks, such as processual and cognitive managerial strategies. These factors and conditions exert an influence to the collaborative process among the project partners by either facilitating the process, or mostly hindering it (see section 6.6.2.). Second, the four main explanatory factors to the evolution of interdisciplinarity have been discovered, coupled with two additional conditions, facilitating this progress. First of all, the fact that a large portion of the Globaqua Consortium partners already know each other from the past projects serves as a factors, strongly enhancing interdisciplinarity in the project. This finding, in fact, conforms to the statement, made by Emerre (2013), based on the past research that having experienced collaborators with extensive

institutional and external networks is essential, and should be encouraged. Then, the evolutionary improvement of the atmosphere in the project has been found to be another explanatory factor to the progress of interdisciplinary, captured in this research. In addition, challenges of various types has been discovered to be of a relatively low level in the project. The tendency of challenges in Globaqua has been found to be steadily decreasing, suggesting that ever diminishing level of challenges, present in the project is adversely related to a continuous progress of scientific knowledge integration in Globaqua. Finally, interviews have revealed a high level of self-organisation prevailing among project partners on a group level. When the guidance from the Management Team in the project is missing, participants have acknowledged self-organising capacity of the team being solid, and enhancing interdisciplinary collaboration with one another, when it is deemed as necessary. As a result, project partners have developed additional to the pre-set interaction channels and pathways that have been observed as facilitating and ensuring interdisciplinary work in the Consortium on a group level. In addition to the four explanatory factors, as stated above, two supporting conditions should be noted as contributing to an explanation of a progress of interdisciplinarity in the project. The first facilitating factor is overall high willingness and interest in the topic of project partners, whilst the second – the fact that the Globaqua Consortium is relatively experienced in IDR projects.

Fourth, similarly as interdisciplinarity dimensions, collaborative team learning process has been found to be evolving in Globaqua in accordance to the stages, distinguished in the conceptual model of this study. Sufficient evidence in this respect has been found from both data sets on the well-developed evolution of the collaborative efforts stage in terms of atmosphere and challenges since the beginning of the project up to date. Also, the data suggests indications of the second stage – collaborative capacity to be advanced in terms of constructive conflict and trust among project partners. There is not, however, enough evidence of this stage to be fully developed on the project level as conclusive indications have been mainly found with regard to constructive conflict. Meantime, trust among partners has been observed only in some cases on a group collaboration, which does not necessarily suggest the same tendency on the project level. Finally, interdisciplinary collaboration stage, as a mode of doing research in Globaqua, has been observed as developing alongside the two other stages, rather than being the final stage of team learning behaviour. The latter, therefore, conforms to the finding of the evolutionary aspect of interdisciplinarity dimensions, taking place in parallel instead of in turn.

Lastly, with regard to scientific measurement of interdisciplinarity progress, a certain limitation of the survey data has put to this research. First, the evolution of interdisciplinarity overall in Globaqua was not possible to be traced alongside the whole life-course of the project up to date due to the way the survey data was collected. Three different types of questionnaires have been designed in relation to three different types of Globaqua meetings. As such, the data remained limited to be compared only between the same types of meetings. Nonetheless, the added value of this research is the methodological choice to combine both quantitative and qualitative methods in measuring the progress of scientific knowledge integration. Not only it allowed justifying the statistical data analysis, but also enhanced the findings of this study significantly by revealing a range of determinants, influencing the process of interdisciplinary collaboration in Globaqua.

8.2. Recommendations

8.2.1. Scientific

This research has provided a foundation for future attempts to measure a progress of scientific knowledge integration in similar large scale interdisciplinary endeavours. As such, the three constructs of interdisciplinarity dimensions – interactive research, integrative understanding, and effectiveness in advancing understanding, previously developed by van Meerkerk and Slob in the ARCH Report (2013), have demonstrated acceptable to excellent scale reliability (with some minor deviations), and hence can be invoked for further use and development in future studies.

Moreover, as the second level integration, discovered during the interviews of this study, is not covered by the three interdisciplinarity constructs of the survey questionnaires, it may be reasonable to measure it based upon a newly developed scale in the last phase of Globaqua. Up to date, many different activities have been carried out by different disciplines and on various scales in the project. The question, how all these will eventually be integrated remains open, and can be addressed in a year or two time. For this research, a newly developed measurement of the process and outcome of second level integration could be investigated by employing a triangulation of quantitative and qualitative methods, as in this research. This may enable more accurate assessments of the different types of integration, taking place in IDR initiative.

Furthermore, when aiming to capture an evolutionary aspect of scientific knowledge integration, it may be more coherent to monitor the degree of interdisciplinarity via survey questionnaires not in line with specific types of meetings, but on a continuous basis throughout the life-course of the project, for instance, every six months, depending on the length of the project, and the organisation of the project activities. In addition, the surveys should be designed for evaluating the overall degree of interdisciplinarity in the project, rather in different types of meetings. In this way, the limitation of having not fully comparable data from different types of meetings is likely to be overcome.

Lastly, as it has been demonstrated in this research, in order to capture the real picture of interdisciplinarity progress, it is crucial to apply a triangulation of quantitative and qualitative methods, and combine the results of both analyses, when explaining the evolutionary aspect of scientific knowledge integration. The same use of methods, thus, is recommended to future studies.

8.2.2. Project design

What concerns recommendations for IDR projects organisation and coordination, a wider range of aspects is to be noted. First, when organising similar IDR projects, in order to prevent the confusion that is currently present in Globaqua in terms of vague project goals and unclear strategy for achieving common objectives in the project, it is crucial to make project goals explicit, and set concrete expectations for and of the project partners in the very early stage of the project. This task is ideally to be undertaken by the Management Team, and may be implemented in a wide range of ways: in formal meetings, bilateral partner meetings, specific interactive workshops, and other.

Second, it is highly recommended to re-write the DoW in the middle of IDR project to adjust the pre-set project design. The reason and importance of this has been already addressed in section 6.6.2.: some of the project partners are more focused on their own work, whilst others are willing to collaborate, produce joint papers, and see the added value in sharing data and resources. Having this in mind, it is about the time to re-write the initially set collaborative work-plan in Globaqua. That may allow avoiding stalemates and gaps in delivering tasks and deliverables, and may enhance truly fruitful and freewill collaboration among the project partners.

The third remark closely relates to the above point – being explicit in how particular results and inputs will contribute to solving the core complex question or issue in the project is crucial. That is to say that discussing the role of certain activities undertaken in Globaqua (or any other project) has to be discussed and understood prior implementing them and producing particular results. Otherwise, there might not be a possibility to re-do the process, and improve the results. In Globaqua context, this aspect relates to some of the case studies, but is not limited to them, and appeals to various smaller scale experiments and decision-making. Having decided upon what particular data and results are important to have in the project in advance not only would facilitate the later stage integration of inputs, but also make the researchers more aware of their work and role in the project.

Fourth, it is essential to leave a room for scientific disciplinary work of single or a few disciplines in addition to interdisciplinary collaboration. Not only this would satisfy certain scientists, but also would enhance the scientific outcome of interdisciplinary collaboration at the end. That is to say that the core problem to be addressed in IDR project has to be complex and specific, not abstract. Then it would enable a wide range of disciplinary results and inputs to be integrated in the later stages of the project, whilst scientific knowledge and practice integration would naturally occur.

Finally, there is a risk to underestimate the importance of processual and cognitive management in the project from the perspective of project management. Structural management is seen as the primary responsibility of the Management Team in Globaqua, whilst the other two – processual and cognitive management strategies remain somewhat undertaken on a group level, leaving the project level with considerable gaps in connecting different disciplines and partners, also, encouraging knowledge exchange, and facilitating interdisciplinary learning on a project level. With this in mind, ensuring process and knowledge management in IDR projects is crucial.

References

1. Abbott, A. (2001). *Chaos of Disciplines*. Chicago: University of Chicago Press;
2. Aboelela, S. W., Larson, E., Bakken, S., Carrasquillo, O., Formicola, A., Glied, S. A., Haas, J., Gebbie, K. M. (2007). Defining Interdisciplinary Research: Conclusions from a Critical Review of the Literature. *Health Services Research, 42*(1), Part I, 329-346;
3. Andrews, A. B. (1990). Interdisciplinary and Interorganizational Collaboration. In Minahan, A. (Ed). *Encyclopedia of Social Work*. 18th edition, p. 175-188, Washington DC: NASW Press;
4. Barron, B. (2003). When Smart Groups Fail. *The Journal of the Learning Sciences, 12*, 307-359;
5. Berg-Weger, M. & Schneider, F. D. (1998). Interdisciplinary Collaboration in Social Work Education. *Journal of Social Work Education, 34*(1), 97-107;
6. Billups, J. O. (1987). Interprofessional Team Process. *Theory Into Practice, 26*(2), p. 146-152;
7. Boix-Mansilla, V. (2006). Assessing Expert Interdisciplinary Work at the Frontier: an Empirical Exploration. *Research Evaluation, 15*(1), 17-29;
8. Boone, H., N. & Boone, D. A. (2012). Analyzing Likert Data. *Journal of Extension, 50*(2). Article number 2TOT2;
9. Bronstein, L. R. (2003). A Model for Interdisciplinary Collaboration. *Social Work, 48*(3), 297-306;
10. Bruce, A., Lyall, C., Tait, J. & Williams, R. (2004). Interdisciplinary Integration in Europe: the Case of the Fifth Framework Programme. Futures 36, 457-470;
11. Corney, R. H. (1989). Collaboration or Conflict: Factors Affecting Interdisciplinary Teamwork. In Hippius, H., Lauter, H., Ploog, D., Bieber, H. & van Hout, L. (Eds.). *Rehabilitation in der Psychiatrie.* Berlin: Springer-Verlag, p. 79-89;
12. Cortina, J. M. (1993). What is Coefficient Alpha? An Examination of Theory and Applications. *Journal of Applied Psychology, 78*(1), 98-104;
13. Damia Barcelo (2013). Managing the Effects of Multiple Stressors on Aquatic Ecosystems under Water Scarcity. *European Commission, 7th Framework Programme for Research, Technological Development, and Demonstration. Globaqua Project Proposal,* 1-225;
14. Dillenbourg, P., Baker, M., Blaye, A. & O'Malley, C. (1996). The Evolution of Research on Collaborative Learning. In Spada, E. & Reiman, P. (Eds.). *Learning in Humans and Machine: Towards an Interdisciplinary Learning Science,* p. 189-211. Oxford, UK: Elsevier;
15. Edelenbos, J. & Eshuis, J. (2012). The Interplay Between Trust and Control in Governance Processes: A Conceptual and Empirical Investigation. *Administration and Society, 44*(6), 647-674;
16. Emerre, M. (2013). Collaboration in Scientific Research: The Views and Practices of Researchers in the College of Sciences, Massey University, Turitea Campus. A Case Study. PhD Thesis at Massey University, Wellington, New Zealand, 1-318;
17. European Council (2000). Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy. *Official Journal of the European Communities*;

18. Farrell, M., Schmitt, M. & Heinemann, G. (2009). Informal Roles and the Stages of Interdisciplinary Team Development. *Journal of Interprofessional Care, 15*(3), 281-295;
19. Folke, C. (2006). Resilience: The Emergence of a Perspective for Social-Ecological Systems Analyses. *Global Environmental Change, 16,* 253-267;
20. Gray, B. (2008). Enhancing Transdisciplinary Research through Collaborative Leadership. *American Journal of Preventive Medicine, 35*(2S)*,* S124-S132;
21. Greene, J. C. & McClintock, C. (1985). Triangulation in Evaluation Design and Analysis Issues. *Evaluation Review, 9,* 523-545;
22. Greene, J. C., Caracelli, V. J. & Graham, W. F. (1989). Toward a Conceptual Framework for Mixed-Method Evaluation Designs. *Educational Evaluation and Policy Analysis, 11*(3), 255-274;
23. Hall, K. L., Stokols, D., Moser, R. P., Taylor, B. K., Thornquist, M. D., Nebeling, L. C., Ehret, C. C., Barnett, M. J., McTiernan, A., Bergern, N. A., Goran, M. I. & Jeffery, R. W. (2008). The Collaboration Readiness of Transdisciplinary Research Teams and Centres: Findings from the National Cancer Institute's TREC Year-One Evaluation Study. *American Journal of Preventive Medicine, 35*(2S), S161-S172;
24. Heathwaite, A. L. (2010). Multiple Stressors on Water Availability at Global to Catchment Scales: Understanding Human Impact on Nutrient Cycles to Protect Water Quality and Water Availability in the Long Term. *Freshwater Biology, 55,* 241-257;
25. Hord, S. M. (1986). A Synthesis of Research on Organizational Collaboration. *Educational Leadership.* Copyright by the Association for the Supervision and Curriculum Development, 22-26;
26. Huutoniemi, K., J. T. Klein, H. Bruun, & J. Hukkinen (2010). Analyzing Interdisciplinarity Typology and Indicators. *Research Policy, 39*(1), 79-88;
27. Klein, J. T. (1990). *Interdisciplinarity. History, Theory and Practice.* Detroit: Wayne State University Press;
28. Klein, J. T. (1996). *Crossing boundaries: Knowledge, Disciplinarities, and Interdisciplinarities.* The USA: The University Press of Virginia;
29. Klein, J. T. (2008). Evaluation of Interdisciplinary and Transdisciplinary Research: A Literature Review. *American Journal of Preventive Medicine, 35*(2S), S116-123;
30. Klijn, E. H., Edelenbos, J. & Steijn, B. (2010). Trust in Governance Networks: Its Impacts on Outcomes. *Administration and Society, 42*(2), 193-221;
31. Kramer, R. M. (2010). Collective Trust within Organizations: Conceptual Foundations and Empirical Insights. *Corporate Reputation Review, 13*(2), 82-97;
32. Krott, M. (2003). Evaluation of Transdisciplinary Research. In *Encyclopedia of Life Support Systems (EOLSS).* Oxford: EOLSS Publishers;
33. Lehnert, M., Miller, B. & Wonka, A. (2007). Increasing the Relevance of Research Questions: Considerations on Theoretical and Social relevance in Political Science. In Gschwend. T. & Schimmelfenning, F. (Eds.), *Research Design in Political Science.* London: Palgrave Macmillan, p. 21-38;
34. Lyall, C., Bruce, A., Tait, J. & Meagher, L. A. (2007). Short Guide to Reviewing Interdisciplinary Research Proposals. *ISSTI Briefing Note No. 2;*
35. Marshall M. N. (1996). Sampling for Qualitative Research. *Family Practice, 13*(6), *Oxford University Press,* 522-525;

36. Marzano, M., Carss, D. N. & S. Bell (2006). Working to make interdisciplinarity work: Investing in communication and interpersonal relationships. *Journal of Agricultural Economics*, *57*(2), 185–197;
37. Masse, L. C., Moser, R. P., Stokols, D., Taylor, B. K., Marcus, S. E., Morgan, G. D., Hall, K. L., Croyle, R. T. & Trochim, W. M. (2008). Measuring Collaboration and Transdisciplinary Integration in Team Science. *American Journal of Preventive Medicine, 35*(2S), S151-S160;
38. Mattesich, P. W. & Monsey, B. R. (1992). *Collaboration: What makes it work? A Review of Research Literature on Factors Influencing Successful Collaboration.* 5th edition. Saint Paul, MN: Amherst H. Wilder Foundation;
39. McGrath, E. J. (1978). Interdisciplinary Studies: an Integration of Knowledge and Experience. *Change Report on Teaching 10*(7), 6-9;
40. Meybeck, M. (2003). Global Analysis of River Systems: from Earth System Controls to Anthropocene Syndromes. *Philosophical Transactions of The Royal Society B: Biological Sciences, 358*(1440)*,* 1935-1955;
41. Meyerson, D., Weick, K. E. & Kramer, R. M. (1996). Swift Trust and Temporary Groups. In Kramer, R. M. & Tyler, T. R. (Eds.). *Trust in Organizations: Frontiers of Theory and Research*, p. 166-195. Thousand Oaks, California: SAGE Publications;
42. Miskovic, M. (2011). Welcome (back) to the old world: A review of Peter Swanborn's *Case study research: What, why and how? The Qualitative Report, 16*(2), 617-621;
43. Newell, W. H. (2001). A Theory of Interdisciplinary Studies. *Issues in Integrative Studies, 19,* 1-25;
44. Official Globaqua Project Website (2016), available at: http://www.globaqua-project.eu/en/home/;
45. Olivera, F., & Straus, S. G. (2004). Group-to-individual Transfer of Learning. Cognitive and Social factors. *Small Group Research, 35*, 440-465;
46. Olson, G. M. & Olson, J. S. (2000). Distance Matters. Human-Computer Interaction. *Human-Computer Interaction, 15*(2), 139-178;
47. Petts, J., Owens, S. & Bulkeley, H. (2008). Crossing Boundaries: Interdisciplinarity in the Context of Urban Environments. *Geoforum, 39,* 593-601;
48. Porter, A. L. & Rafols, I. (2009). Is Science Becoming More Interdisciplinary? Measuring and Mapping Six Research Fields over Time. *Scientometrics, 81*(3), 719-745;
49. Porter, A. L., Roessner, J. D. & Heberger, A. E. (2008). How Interdisciplinary is a Given Body of Research? *Research Evaluation, 17*(4), 273-282;
50. Sabater, S. Acuna, V., Batalla, R. J., Balcazar, J. L., Borrego, C., Insa, S., Marce, R., Pla, J. M., Petrovic, M., Pijuan, M., Rodriguez-Mozaz, S., Rodriguez-Roda, I., Villagrasa, M. & Barcelo, D. (2014). Water Research in the Mediterranean: Challenges and Perspectives. The Catalan Institute for Water Research (ICRA). *Contributions to Science, 10,* 207-220;
51. Schenk, T., Vogel, R. A. L., Maas, N. & Tavasszy, L. A. (2016). Joint Fact-Finding in Practice: Review of a Collaborative Approach to Climate-Ready Infrastructure in Rotterdam. *EJTIR, 16*(1), 273-293;
52. Slob, A., & Duijn, M. (2014). Improving the Connection between Science and Policy for River Basin Management. In Brils, J., Brack, W., Muller-Grabherr, D., Negrel, P. & Vermaat, J. E. (Eds.). *Risk-Informed Management of European River Basins. The Handbook of Environmental Chemistry.* Springer-Verlag Berlin Heidelberg, p. 347-364;

53. Smitz, D. & Katz, S. J. (2000). Collaborative Approaches to Research. Final Report. *HEFCE Fundamental Review of Research Policy and Funding*, 1-117;
54. Soler, M. & Shauffer, C. (1993). Fighting Fragmentation. Coordination of Services for Children and Families. *Education and Urban Society, 25*(2), 129-140;
55. Stahl, G. (2000). A Model of Collaborative Knowledge Building. In Fishman, B. & O'Connor-Divelbiss, S. (Eds.), *Fourth International Conference of the Learning Sciences,* 70-77. Mahwah, NJ: Erlbaum;
56. Swanborn, P. G. (2013). *Case Studies: Wat, Wanneer en Hoe?* 5th geheel herziene druk. Den Haag: Boom Lemma uitgevers;
57. Tait, J. & Lyall, C. (2007). Short Guide to Developing Interdisciplinary Research Proposals. *ISSTI Briefing Note, No. 1,* 1-4;
58. The National Academies – Academy of Sciences, National Academy of Engineering, Institute of Medicine (2005). *Facilitating Interdisciplinary Research.* Washington: The National Academies Press;
59. Thompson, J. L. (2009). Building Collective Communication Competence in Interdisciplinary Research Teams. *Journal of Applied Communication Research, 37*(3), 278-297;
60. Van den Bossche, P., Gijselaers, W. H., Segers, M. & Kirschner, P. A. (2006). Social and Cognitive Factors Driving Teamwork in Collaborative Learning Environments. *Small Group Research, SAGE Publications, 37*(5), 490-521;
61. Van Meerkerk, I. F. & Slob, A. (2013). Scientific Knowledge Integration: Evaluation of the Interdisciplinary Process in ARCH. Project deliverable for the European (FP7) research project Architecture and roadmap to manage multiple pressures on lagoons (Arch);
62. Van Rijnsoever, F. J. & Hessels, L. K. (2011). Factors Associated with Disciplinary and Interdisciplinary Research Collaboration. *Research Policy, 40,* 463-472;
63. Vorosmarty, C. J., McIntyre, P. B., Gessner, M. O., Dudgeon, D. & Prusevich, A. (2010). Global Threats to Human Water Security and River Biodiversity. *Nature, 467*(7315), 555-561;
64. Welch IV, J. (2011). The Emergence of Interdisciplinarity from Epistemological Thought. *Issues in Integrative Studies, 29,* 1-39.
65. World Water Assessment Programme – WWAP (2009). *The United Nations World Water Development Report 3: Water in a Changing World.* Paris: UNESCO, and London: Earthscan.

Appendices

Appendix 1

Appendix 1. Mean scores on interdisciplinarity dimensions by the unique codes of the survey respondents

Unique code	General Assembly (2014 November) (N = 42)			Module meeting (2015 May) (N = 18)			Sampling campaign (2015 July) (N = 16)			Sampling campaign (2015 September) (N = 13)			Module meeting (2015 November) (N = 27)			General Assembly (2016 January) (N = 45)			Module meeting (2016 April) (N=27)		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
AA66	-	-	-	-	-	-	-	-	-	5	5	5	-	-	-	-	-	-	-	-	-
AA76	2.5	4.3	4.7	-	-	-	-	-	-	-	-	-	4	4	4	-	-	-	-	-	-
AA90	-	-	-	-	-	-	5	5	5	-	-	-	-	-	-	3.5	3.7	4.5	-	-	-
AC72	3.75	4.3	4	-	-	-	-	-	-	-	-	-	3.7	4	3.8	4	4	4.7	-	-	-
AE53	-	-	-	-	-	-	-	-	-	-	-	-	4	4	3.7	3.75	4	4.3	4	5	5
AE62	-	-	-	2.5	3.5	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AM60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	2.7	4	-	-	-
AM91	3.75	3.7	4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AN79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3.3	4
AN84	-	-	-	-	-	-	-	-	-	5	5	5	-	-	-	-	-	-	-	-	-
AS53	3.25	3.7	4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AS76	3	2.7	3.8	2	3.5	3	-	-	-	-	-	-	3.3	4	3.8	-	-	-	-	-	-
AT80	-	-	-	-	-	-	5	5	3.25	-	-	-	-	-	-	-	-	-	-	-	-
AV76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	3	3.8	-	-	-
BF53	3.75	4.3	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BG83	-	-	-	-	-	-	5	5	5	-	-	-	4.3	4	4	4	4	4	-	-	-
BL64	1.25	1	3.2	-	-	-	-	-	-	-	-	-	-	-	-	3.25	2.7	2.8	-	-	-
BR76	3.5	2.7	4	3.5	3	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BS79	3.75	3.3	4	-	-	-	-	-	-	4.5	5	5	-	-	-	-	-	-	4.3	4.7	3.7
BV86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5
CC74	4.25	4	5	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5	5	-	-	-
CN57	3.5	3.3	3.8	-	-	-	-	-	-	-	-	-	4.3	4	4	3.5	4	4.7	-	-	-
CP86	-	-	-	-	-	-	5	3.7	4.25	-	-	-	-	-	-	-	-	-	-	-	-
DA69	-	-	-	4	4	3.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

DA87	-	-	-	3	4	4.8	-	-	-	-	-	-	-	-	-	4.25	4.7	5	-	-	-
DC69	3.75	3.3	4	4	4	3.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DE73	-	-	-	4	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DE90	3.75	4	4.3	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4.5	-	-	-
DJ90	-	-	-	-	-	-	-	-	-	5	0	5	-	-	-	-	-	-	-	-	-
DM84	-	-	-	-	-	-	5	5	4.75	-	-	-	-	-	-	-	-	-	-	-	-
DO62	-	-	-	-	-	-	5	5	5	-	-	-	-	-	-	-	-	-	-	-	-
DO78	3.5	4	4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EC82	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.75	4.7	5
EK83	3.75	3	4.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EO87	-	-	-	-	-	-	4	4	5	-	-	-	-	-	-	-	-	-	-	-	-
EP84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	4
EP87	4.5	4.3	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EP89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.75	4	4.2	-	-	-
FA80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.75	3.7	3.8	-	-	-
FE54	3.5	4	5	-	-	-	-	-	-	-	-	-	4	4	5	4.5	5	5	-	-	-
FE59	-	-	-	4	4.5	4.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FF84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	3.7	3.5	-	-	-
FM66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.25	4	3.8
GA62	3.25	3.7	4.3	3.75	4	3.3	5	5	5	-	-	-	4	4.7	4.3	4.5	4.3	4.3	4.25	4.3	4.5
FM90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	4.7	4.5
GK71	3.25	4	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GM75	2.25	2.7	3.5	-	-	-	4.5	4.3	4.75	-	-	-	-	-	-	3.75	3.3	3.8	-	-	-
GM76	-	-	-	-	-	-	2.5	2.3	1.5	-	-	-	-	-	-	-	-	-	-	-	-
GM82	-	-	-	-	-	-	2	2.7	3.75	-	-	-	-	-	-	-	-	-	-	-	-
GP67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.7	4.7	-	-	-
GS90	-	-	-	-	-	-	5	5	5	-	-	-	-	-	-	1.75	3	3	-	-	-
HA70	-	-	-	3.25	4	3.5	-	-	-	-	-	-	3.3	4	3.3	2.75	2.7	3.7	-	-	-
HB88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.25	5	4.8
HH64	-	-	-	-	-	-	-	-	-	4.5	4.3	4.5	5	4.3	4.5	4.75	4	4.3	-	-	-
HY80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4
IA65	3.25	3.4	4	3.25	3	4.5	-	-	-	-	-	-	4	4	3.7	4	4	4.7	-	-	-
IN72	-	-	-	-	-	-	-	-	-	5	3	5	-	-	-	-	-	-	5	5	5
JA91	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	4	4.7	-	-	-
JE87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.25	3.3	4.7	-	-	-
JD80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.25	4	5
JH80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	4	4.7	3	2	4.3

JI68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.75	5	5
JI78	4.75	3	4.2	-	-	-	-	-	-	-	-	-	4.3	4	3.8	4	3.7	4.3	-	-	-
JJ84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.7	4.2
JJ87	-	-	-	-	-	-	-	-	-	-	-	-	4.3	5	4.7	5	5	5	-	-	-
JL87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.25	4.3	4	-	-	-
JM62	4.25	3.7	4.2	3.75	4	4.3	5	5	4.25	5	5	5	4.3	4.3	4.5	4.5	4	4.5	-	-	-
JM71	-	-	-	-	-	-	-	-	-	5	5	5	-	-	-	-	-	-	-	-	-
JM87	-	-	-	-	-	-	-	-	-	-	-	-	4.6	4.3	4.5	-	-	-	-	-	-
KA70	4.25	4.4	4.2	-	-	-	-	-	-	-	-	-	4	3.3	4.7	-	-	-	-	-	-
KC87	-	-	-	-	-	-	-	-	-	-	-	-	4.3	5	4	4.25	4	4.2	-	-	-
LD80	4.25	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LH58	3.25	4	4	4	4	3.5	-	-	-	-	-	-	-	-	-	4	4.3	4	-	-	-
LK00	5	4	3.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LR83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	4	4.8
MA55	4.75	5	4.4	-	-	-	-	-	-	5	5	5	5	5	5	4.25	5	5	4.5	5	4.7
MA61	3.75	4.4.	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MC78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.75	3	3.8	-	-	-
MD68	-	-	-	-	-	-	4.5	5	5	-	-	-	-	-	-	4.5	5	5	5	5	4.7
MG62	4	3	4	-	-	-	-	-	-	-	-	-	4	4.7	4.7	4.25	4.3	4.5	4	4	4.3
MG74	3.75	3.7	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.5	3	3.3
MJ62	-	-	-	-	-	-	-	-	-	5	0	5	-	-	-	-	-	-	-	-	-
MJ67	3.75	3.4	4.4	-	-	-	-	-	-	-	-	-	4.3	4.7	3.8	4.5	3.7	4.8	-	-	-
ML64	-	-	-	-	-	-	3	4	0	-	-	-	-	-	-	-	-	-	-	-	-
MM77	4	3	4	3.75	3	3.8	-	-	-	5	4.3	3.75	-	-	-	-	-	-	-	-	-
MN75	-	-	-	-	-	-	3.5	4	5	-	-	-	-	-	-	-	-	-	-	-	-
MR85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.75	3	4.7	-	-	-
NP64	3.75	3.4	4.8	-	-	-	-	-	-	-	-	-	3.7	3	4.2	-	-	-	-	-	-
NR73	3.25	2	4.3	-	-	-	-	-	-	-	-	-	-	-	-	3.25	3.7	3.8	-	-	-
NV61	-	-	-	4	4	3.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OF88	-	-	-	-	-	-	-	-	-	-	-	-	4	3.7	4.5	-	-	-	-	-	-
PE90	4	3	4.7	4.75	5	5	-	-	-	-	-	-	-	-	-	4.75	4.7	5	-	-	-
PJ84	-	-	-	-	-	-	-	-	-	4	4	5	-	-	-	-	-	-	-	-	-
PL71	3.75	3.7	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.3	4.8
PM90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.75	3	3.5	-	-	-
PR90	-	-	-	-	-	-	-	-	-	-	-	-	2.7	4.7	4.8	-	-	-	-	-	-
PZ90	4.75	4.7	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RL67	2.5	3	3.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

SA86	3.75	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	5
SE74	-	-	-	3.25	4	4.3	-	-	-	-	-	-	4	4	4.3	4	4	4	-	-	-
SH58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4
SM86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5	3.7	-	-	-
SV63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	4	-	-	-
SV85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	4	4	5	4.3	4.8
TA58	-	-	-	-	-	-	-	-	-	-	-	-	3	3.3	4.5	-	-	-	-	-	-
VB69	-	-	-	-	-	-	-	-	-	5	5	5	-	-	-	-	-	-	-	-	-
VM66	3.5	4	4.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VV89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.75	4	5
WN85	-	-	-	3	4	3.2	-	-	-	-	-	-	4.3	3.7	3.8	3	3.7	4.2	-	-	-
YE84	4.75	2.4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
XE87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	4	3.8
Total:	**3.7**	**3.6**	**4**	**3.6**	**3.9**	**3.9**	**4.3**	**4.4**	**4.4**	**4.8**	**4.6**	**4.7**	**4.1**	**4.2**	**4.2**	**4**	**3.9**	**4.3**	**4.1**	**4.2**	**4.5**

N – Sample size
1st – Interactive research dimension
2nd – Integrative understanding dimension
3rd – Effectiveness in advancing understanding
– = Not participated in a particular meeting
0 = No score given by the respondent

Source: Developed by the author, based on the statistical survey data analysis

Appendix 2

Appendix 2. Mean scores on interdisciplinarity by gender, disciplinary background, and years of experience in IDR variables

Variables		Interactive research	Integrative understanding	Effectiveness in advancing understanding
General Assembly (2014 November)				
Gender	Male *(N=23)*	3.5	3.5	3.8
	Female *(N=19)*	3.9	3.6	4.3
Type of scientist	Natural scientist *(N=36)*	3.6	3.5	3.9
	Social scientist *(N=5)*	4	3.7	4.6
	Both *(N=1)*	2.5	4.3	4.6
Disciplinary background	Physical Sciences *(N=11)*	3.6	3.8	4.3
	Life Sciences *(N=4)*	3.9	3.5	4.5
	Environmental Sciences *(N=14)*	3.8	3.5	3.8
	Engineering *(N=5)*	2.9	3.2	3
	Social Sciences *(N=5)*	4	3.7	4.6
	Other *(N=3)*	3.7	3.6	4
Experience in IDR projects	0 to 5 years *(N=16)*	4	3.5	4.3
	6 to 10 years *(N=12)*	3.2	3.4	3.9
	11 to 15 years *(N=5)*	3.8	3.5	3.9
	16 to 20 years *(N=6)*	3.6	3.7	4.4
	21 to 25 years *(N=2)*	4.3	4.6	2.2
	26 and more *(N=1)*	3.8	4.3	4
Module meeting (2015 May)				
Gender	Male *(N=11)*	3.6	4.1	4
	Female *(N=7)*	3.4	3.5	3.8
Disciplinary background	Physical Sciences *(N=4)*	3.6	3.8	3.8
	Life Sciences *(N=3)*	3.4	3.8	3.8
	Environmental Sciences *(N=7)*	3.5	3.7	3.9
	Engineering *(N=2)*	3.6	4	3.6
	Social Sciences *(N=1)*	4.8	5	5
	Other *(N=1)*	3	4	4.8
Experience in IDR projects	0 to 5 years *(N=6)*	3.7	4.2	4
	6 to 10 years *(N=5)*	3.3	3.5	3.9
	11 to 15 years *(N=6)*	3.6	3.8	4.1
	16 to 20 years *(N=1)*	4	4	3.5
	21 to 25 years *(N=0)*	-	-	-
	26 and more *(N=0)*	-	-	-
Sampling campaign (2015 July)				
Gender	Male *(N=11)*	4.1	4.3	4.3
	Female *(N=5)*	4.8	4.5	4.7
Disciplinary background	Physical Sciences *(N=4)*	4.9	4.8	4.9
	Life Sciences *(N=3)*	4.5	4.7	5
	Environmental Sciences *(N=4)*	2.8	3.3	3.4
	Engineering *(N=3)*	5	5	4.1
	Social Sciences *(N=0)*	-	-	-
	Other *(N=2)*	5	5	4.1
	0 to 5 years *(N=10)*	4.3	4.3	4.2

Experience in IDR projects	6 to 10 years *(N=3)*	3.8	4	4.5
	11 to 15 years *(N=0)*	-	-	-
	16 to 20 years *(N=2)*	4.8	5	5
	21 to 25 years *(N=1)*	5	5	5
	26 and more *(N=0)*	-	-	-
Sampling campaign (2015 September)				
Gender	Male *(N=5)*	4.7	4.5	4.7
	Female *(N=8)*	4.9	4.6	5
Disciplinary background	Physical Sciences *(N=2)*	4.8	4.6	4.8
	Life Sciences *(N=5)*	4.8	4.8	5
	Environmental Sciences *(N=5)*	4.9	4.3	4.8
	Engineering *(N=0)*	-	-	-
	Social Sciences *(N=0)*	-	-	-
	Other *(N=1)*	5	5	5
Experience in IDR projects	0 to 5 years *(N=4)*	4.8	4	5
	6 to 10 years *(N=4)*	4.8	4.7	4.6
	11 to 15 years *(N=1)*	5	5	5
	16 to 20 years *(N=3)*	5	5	5
	21 to 25 years *(N=0)*	-	-	-
	26 and more *(N=1)*	5	5	5
Module meeting (2015 November)				
Gender	Male *(N=18)*	3.9	4.1	4.2
	Female *(N=9)*	4.3	4.1	4.3
Disciplinary background	Physical Sciences *(N=11)*	4.1	4	4.1
	Life Sciences *(N=4)*	4	4	4.3
	Environmental Sciences *(N=7)*	4.2	4.2	4.3
	Engineering *(N=1)*	3.3	4	3.3
	Social Sciences*(N=2)*	3.5	4.3	4.4
	Other *(N=2)*	4	4.1	4.2
Experience in IDR projects	0 to 5 years *(N=7)*	4.1	4.3	4.3
	6 to 10 years *(N=7)*	3.9	3.9	4
	11 to 15 years *(N=9)*	4	4.1	4.4
	16 to 20 years *(N=3)*	4.4	4.3	4.2
	21 to 25 years *(N=1)*	4	4	4
	26 and more *(N=0)*	-	-	-
General Assembly (2016 January)				
Gender	Male *(N=30)*	4	3.8	4.3
	Female *(N=15)*	3.8	4.1	4.3
Type of scientist	Natural scientist *(N=41)*	3.9	3.8	4.2
	Social scientist *(N=4)*	4.4	4.4	4.7
Disciplinary background	Physical Sciences *(N=17)*	3.9	3.7	4.1
	Life Sciences *(N=5)*	4.2	3.9	4.3
	Environmental Sciences *(N=13)*	4.1	4.2	4.5
	Engineering *(N=3)*	3.4	3.5	4.2
	Social Sciences *(N=4)*	4.4	4.4	4.7
	Other *(N=3)*	3.6	3.5	4.1
Experience in IDR projects	0 to 5 years *(N=19)*	4	4	4.3
	6 to 10 years *(N=12)*	3.8	3.7	4.2
	11 to 15 years *(N=5)*	4	3.6	4
	16 to 20 years *(N=6)*	4.3	4.3	4.8
	21 to 25 years *(N=1)*	3.5	2.7	4

	26 and more *(N=2)*	4.1	4.7	4.5
Module meeting (2016 April)				
Gender	Male *(N=15)*	3.9	4.1	4.4
	Female *(N=12)*	4.3	4.2	4.6
Disciplinary background	Physical Sciences *(N=11)*	4.2	4.4	4.5
	Life Sciences *(N=8)*	4.5	4.4	4.6
	Environmental Sciences *(N=7)*	4	4.1	4.4
	Engineering *(N=0)*	-	-	-
	Social Sciences *(N=1)*	4	4	4
	Other *(N=0)*	-	-	-
Experience in IDR projects	0 to 5 years *(N=16)*	4.1	4.2	4.7
	6 to 10 years *(N=5)*	3.8	3.4	3.9
	11 to 15 years *(N=2)*	3.8	4.2	4.2
	16 to 20 years *(N=2)*	4.9	5	4.8
	21 to 25 years *(N=0)*	-	-	-
	26 and more *(N=2)*	4.3	4.5	4.3

– = Did not participate in the meeting

Source: Developed by the author, based on the statistical survey data analysis

Appendix 3

Appendix 3. List of 25 contractual partners of the Globaqua Consortium

No.	Participant legal name	Country	Organisation type
1	**IDAEA-CSIC** – Agencia Estatal Consejo Superior de Investigaciones Científicas, Institute of Environmental Assessment and Water Research (IDAEA), Barcelona. Coordinator of Globaqua	Spain	Research
2	**ICRA** – Catalan Institute for Water Research, Girona	Spain	Research
3	**EKUT** – Center for Applied Geosciences, Tubingen University, Tubingen	Germany	Academic
4	**UNITN** – Dipartimento di Ingegneria Civile e Ambientale, Universita' di Trento, Trento	Italy	Academic
5	**CNRS-LEHNA** – UMR 5023, Université Claude Bernard, Lyon	France	Academic
6	**ALTERRA** – Stichting Dienst Landbouwkundig Onderzoek (DLO), Climate Change and Adaptive Land and Water Management Team, Wageningen University and Research Centre, Wageningen	The Netherlands	Research
7	**UFZ** – Helmholtz - Centre for Environmental Research, Leipzig	Germany	Research
8	**LMU** – Ludwig-Maximilians-Universität München, Department of Geography, Faculty of Geosciences, München	Germany	Academic
9	**ATHENA** – Athena, Research and Innovation Centre in Information, Communication, Communication and Knowledge Technologies, Athens	Greece	Academic
10	**JSI** – Jožef Stefan Institute, Department of Environmental Sciences, Ljubljana	Slovenia	Research
11	**UPV/EHU** – Faculty of Science and Technology, University of the Basque Country, Bilbao	Spain	Academic
12	**SMHI** – Swedish Meteorological and Hydrological Institute, Rossby Centre, Norrköping	Sweden	Research
13	**UNIPD** – Dipartimento di Geoscienze, Università degli Studi di Padova, Padova	Italy	Academic
14	**IMPERIAL** –The Imperial College of Science, Technology and Medicine, London	United Kingdom	Academic
15	**HCMR** – Hellenic Centre for Marine Research, Institute of Marine Biological Resources & Inland Waters, Athens	Greece	Research
16	**IBISS** – University of Belgrade, Institute for Biological	Serbia	Research
17	**UB** – University of Barcelona, Barcelona	Spain	Academic
18	**TNO** – Netherlands Organisation for Applied Scientific Research	The Netherlands	Research
19	**AEIFORIA –** a spin-off of the Universita Cattolica del Sacro Cuore of Piacenza	Italy	SME
20	**JRC-IES** – Institute for Environment and Sustainability, Ispra, Italy	EU	Research
21	**IAV** – Institute Agronomique et Veterinaire Hassan II, Agadir	Morocco	Research
22	**INRS-ETE** – Institut National de la Recherche Scientifique, Québec City	Canada	Research
23	**TUM –** Technical University of Munich, Munich	Germany	Academic
24	**UNIZG-FAZ –** Sveučiliste u Zagrebu Agronomski Fakultet, Zagreb	Croatia	Academic
25	**WU –** Wageningen University, Wageningen	The Netherlands	Academic

Source: Official Globaqua Project Website (2016)

Appendix 4

Appendix 4. Globaqua collaborative work plan

Module 1 (STRESSORS) comprises five WPs for understanding the mechanisms behind multiple stressors acting in six case studies. **WP1** (DATA) collects existing data from basin authorities and previous research projects, and gathers experimental data so as to provide it to **WP2** (SCENARIOS), which will generate climatic, socio-economic, and land-use scenarios to identify drivers for the impact modelling for **WP4** (GEOMORPH). The latter with **WP3** (HYDROL) and **WP5** (QUALITYCHEM) analyse surface and groundwater hydrological patterns, sediment and pollutant transport, quality of the physical habitat, and the fate of inorganic and organic pollutants. The three WPs need to actively collaborate so as to inform **WP6** (BIOL) and **WP7** (ECOSYSTEM), which both then analyse the effects of the stressors on biodiversity and ecosystem, performing under the supervision of **Module 2** (RECEPTORS). Their research mainly is based on laboratory experiments, and basin-scale surveys, aiming to understand effects of single and multiple stressors at different scales, and to feed statistical integrative models to be developed by **WP8** (SERVICES) in the **Module 3** (IMPLICATIONS). The latter will integrate the information generated by the two preceding WPS, and inform the subsequent **WP9** and **WP10** from the same module to fulfil their interdependent tasks – to assess the impact of the changes in ecosystem services in economic terms on the socio-economic development, and to support the performed ecosystem services valuation by WP10. This will help to identify environmentally and socioeconomically sustainable management of water resources. Furthermore, **Module 4** (ENVIRONMENTAL MANAGEMENT) includes **WP11** (INTEGRATION) and **WP12** (POLICY), dealing with issues associated to the impact of multiple stressors on water quality, quantity, and ecosystems, as well as on the potential implementation of the major findings on European policy respectively. Thus, WP11 will develop a model framework to assess scenarios affecting availability, quality and demand of water at the European scale, and will overall integrate the most relevant results of the previous WPs in other modules to define a manageable perspective on the multi-stressor consequences for European river basins. Meanwhile, the implications of the stressors interactions and their opportunities for the related policy making will be analysed in WP12, which represents a real interface between the scientific results obtained during the project with their policy definition and development. Ultimately, **WP13** (DISSEMINATION) and **WP14** (MANAGE) run during the whole project duration to communicate the results to specific target groups, also, to stimulate their use through relations with stakeholders and end-users, and to efficiently coordinate all activities, day-to-day technical management. It is essential to note that WP14 is exceptionally set to take the two main project management roles within Globaqua. The first one concerns the *management of the Consortium* from the standpoint of partner-related technicalities, such as coordinating management of intellectual property on the project, making strategic decisions regarding the implementation of the project, and generally monitoring the risks threatening the successful completion of the project. The second task – *content management* – associates with the day-to-day management of the actual work on the project, its progress, ensuring the deliverables and milestones have been achieved on time, within the budget, and in the required quality. By doing that, WP14 is responsible for planning, monitoring, and evaluating the progress made by other WPs.

Appendix 5

Appendix 5. Mean scores, and correlations between atmosphere and interdisciplinarity dimensions in Globaqua meetings

Variables	Meetings and correlations		
	First General Assembly (2014 November)		**Second General Assembly (2016 January)**
ATMOSPHERE	**3.8** (relatively high)		**4.5** (high)
Interactive research	No correlation		Significant strong positive correlation (r = 0.520, p = 0.000 (< 0.01), N = 45)
Integrative understanding	No correlation		Significant strong positive correlation (r = 0.622, p = 0.000 (< 0.01), N = 45)
Effectiveness in advancing understanding	Significant strong positive correlation (r = 0.892, p = 0.000 (< 0.01), N = 42)		Significant strong positive correlation (r = 0.721, p = 0.000 (< 0.01), N = 45)
	First Sampling campaign (2015 July)		**Second Sampling campaign (2015 September)**
ATMOSPHERE	**4.5** (high)		**4.6** (high)
Interactive research	Significant positive strong correlation (r = 0.738, p = 0.001 (< 0.01), N = 18)		Not significant correlation
Integrative understanding	Significant positive strong correlation (r = 0.871, p = 0.000 (< 0.01), N = 18)		No correlation
Effectiveness in advancing understanding	Significant positive strong correlation (r = 0.686, p = 0.005 (< 0.01), N = 18)		Not significant correlation
	First Module meeting (2015 May)	**Second Module meeting (2015 November)**	**Third Module meeting (2016 April)**
ATMOSPHERE	**3.7** (relatively high)	**4.2** (relatively high)	**4.5** (high)
Interactive research	Not significant correlation	Not significant correlation	Not significant correlation
Integrative understanding	Significant strong positive correlation (r = 0.491, p = 0.038 (< 0.05), N = 18)	Not significant correlation	Significant strong positive correlation (r = 0.518, p = 0.006 (< 0.01), N = 27)
Effectiveness in advancing understanding	Not significant correlation	No correlation	Not significant correlation

Source: Developed by the author, based on the statistical survey data analysis

Appendix 6

Appendix 6. Mean scores, and correlations between challenges and interdisciplinarity dimensions in Globaqua meetings

Variables	**Meetings and correlations**		
	First General Assembly (2014 November)	**Second General Assembly (2016 January)**	
CHALLENGES (mean)	**2.5** (moderate)	**2.5** (moderate)	
Interactive research	Not significant correlation	Significant strong negative correlation (r = -0.522, p. = 0.000 (< 0.01), N = 45)	
Integrative understanding	Significant moderate negative correlation (r = -0.467, p = 0.002 (< 0.01), N = 42)	Significant strong negative correlation (r = -0.522, p. = 0.000 (< 0.01), N = 45)	
Effectiveness in advancing understanding	Significant moderate negative correlation (r = -0.477, p = 0.001 (< 0.01) N = 42)	Significant moderate negative correlation (r = -0.471, p = 0.001 (< 0.01), N = 45)	
	First Sampling campaign (2015 July)	**Second Sampling campaign (2015 September)**	
CHALLENGES (mean)	**1.6** (relatively low)	**1.2** (low)	
Interactive research	Not significant correlation	Significant strong negative correlation (r = -.0752, p = 0.003 (< 0.01), N = 13)	
Integrative understanding	Significant strong negative correlation (r = -0.53, p = 0.035 (< 0.05), N = 16)	Not significant correlation	
Effectiveness in advancing understanding	Significant strong negative correlation (r = -.0775, p = 0.001 (< 0.01), N = 15)	Not significant correlation	
	First Module meeting (2015 May)	**Second Module meeting (2015 November)**	**Third Module meeting (2016 April)**
CHALLENGES (mean)	**2.6** (moderate)	**2.7** (moderate)	**2.5** (moderate)
Interactive research	Not significant correlation	Not significant correlation	No correlation
Integrative understanding	No correlation	Significant moderate negative correlation (r = -0.409, p = 0.034 (< 0.05), N = 27)	No correlation
Effectiveness in advancing understanding	Not significant correlation	Not significant correlation	No correlation

Source: Developed by the author, based on the statistical survey data analysis

Appendix 7

Appendix 7. Mean scores of and correlations between managerial strategies and interdisciplinarity, atmosphere and challenges variables in Module meetings

Variables	First Module meeting (2015 May)	Second Module meeting (2015 November)	Third Module meeting (2016 April)
PROCESSUAL STRATEGIES (mean)	**4** (relatively high)	**4.3** (relatively high)	**4.4** (relatively high)
Interactive research	Significant strong positive correlation (r = 0.574, p = 0.13 (< 0.05), N = 18)	No correlation	Significant strong positive correlation (r = 0.552, p = 0.005 (< 0.01), N = 27)
Integrative understanding	Not significant correlation	No correlation	Significant strong positive correlation (r = 0.557, p = 0.003 (< 0.01), N = 27)
Effectiveness in advancing understanding	Not significant correlation	Not significant correlation	Significant moderate positive correlation (r = 0.499, p = 0.008 (< 0.01), N = 27)
Atmosphere	Not significant correlation	Not significant correlation	Significant strong positive correlation (r = 0.586, p = 0.001 (< 0.01), N = 27)
Challenges	Significant strong negative correlation (r = -0.557, p = 0.016 (< 0.05)	Not significant negative correlation	Not significant negative correlation
STRUCTURAL STRATEGIES (mean)	**3.8** (relatively high)	**4** (relatively high)	**4.6** (high)
Interactive research	Not significant correlation	No correlation	Significant strong positive correlation (r = 0.586, p = 0.001 (< 0.01), N = 27)
Integrative understanding	Not significant correlation	No correlation	Significant strong positive correlation (r = 0.622, p = 0.001 (< 0.01), N = 27)
Effectiveness in advancing understanding	Not significant correlation	Not significant correlation	Significant strong positive correlation (r = 0.592, p = 0.001 (< 0.01), N = 27)
Atmosphere	Not significant correlation	Not significant correlation	Significant moderate positive correlation (r = 0.427, p = 0.026 (< 0.05), N = 27)
Challenges	Significant strong negative correlation (r = -0.619, p = 0.006 (< 0.01), N = 18)	Not significant negative correlation	No correlation
COGNITIVE STRATEGIES (mean)	**3.8** (relatively high)	**3.8** (relatively high)	**4.4** (relatively high)
Interactive research	Significant strong positive correlation (r = 0.571, p = 0.013 (< 0.05), N = 18)	No correlation	Significant moderate positive correlation (r = 0.499, p = 0.008 (< 0.01), N = 27)
Integrative understanding	Significant strong positive correlation (r = 0.610, p = 0.007 (< 0.05), N = 18)	Not significant correlation	Significant moderate positive correlation (r = 0.497, p = 0.008 (< 0.01), N = 27)
Effectiveness in advancing understanding	Significant moderate positive correlation (r = 0.468, p = 0.05 (= 0.05), N = 18)	Not significant correlation	Significant strong positive correlation (r = 0.617, p = 0.001 (< 0.01), N = 27)
Atmosphere	Not significant correlation	Not significant correlation	Significant moderate positive correlation (r = 0.462, p = 0.015 (< 0.05), N = 27)
Challenges	Not significant negative correlation	Significant moderate negative correlation (r = -0.388, p = 0.045 (< 0.05), N = 27)	No correlation

Source: Developed by the author, based on the statistical survey data analysis

Annexes

Annex 1

Annex 1. Globaqua General Assembly survey questionnaire

Questionnaire 1: Knowledge integration in General Assembly

Introduction to the survey

Dear participant of the GLOBAQUA research project,

In the next pages you will find a questionnaire by which we will follow the progress of knowledge integration in GLOBAQUA. This monitoring of knowledge integration is part of the activities of WP 12 and will provide the overall project management, WP-leaders and module leaders feedback information on the progress of the integration process during the lifetime of the project.

The questionnaire will take about 10 minutes to fill in. Respondents will stay anonymous.

For more information about the survey, you can contact Adriaan Slob [adriaan.slob@tno.nl] or Tara Geerdink [tara.geerdink@tno.nl]

Questions to track the data

Explanation

The following questions are used to track the data in time. Respondents stay anonymous, only the questionnaires themselves are coded in order to follow the data! We will ask you to provide the first letter of your father's and mother's name. Together with the year of birth we are able to code the questionnaire.

1. What is the first letter of your father's first name? Please circle one of the letters below

A—B—C—D—E—F—G—H—I—J—K—L—M—N—O—P—Q—R—S—T—U—V—W—X—Y—Z

2. What is the first letter of your mother's first name? Please circle one of the letters below

A—B—C—D—E—F—G—H—I—J—K—L—M—N—O—P—Q—R—S—T—U—V—W—X—Y—Z

3. What is your year of birth? (Only the last two numbers; 1978 = 78)

General control questions

4. What is your sex?

Male

Female

5. Broadly defined, I consider myself a –

Natural scientist

Social scientist

6. What is your disciplinary background? Please tick one category: choose the disciplinary category in which you are mostly educated.

Physical sciences (includes physics, earth sciences, chemistry)

Life sciences (includes biology, genetics, medical sciences)

Environmental sciences

Engineering

Social sciences (includes economics, sociology, political science, psychology)

Humanities (includes philosophy, history, arts)

Other, please specif

7. How many years of experience do you have in <u>interdisciplinary</u> research projects?

….. year(s).

8. In which work package(s) are you participating? (Multiple answers possible)

WP 1	WP 8
WP 2	WP 9
WP 3	WP 10
WP 4	WP 11
WP 5	WP 12
WP 6	WP 13
WP 7	WP 14

Questions on knowledge integration in GLOBAQUA

Explanation

The following questions are all about knowledge integration and interdisciplinary research, research which is based on active interaction across disciplinary fields.

9. Please rate the following statements about interdisciplinary research orientation. Please rate all statements.

Interdisciplinary orientation in GLOBAQUA (personal)	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
In my own work for GLOBAQUA, I typically incorporate perspectives from disciplinary orientations that are different from my own					

Although I am trained in a particular discipline, I devote much of my time in GLOBAQUA to understanding other disciplines in order to inform my research for GLOBAQUA					
I would describe myself as someone who strongly values interdisciplinary or transdisciplinary collaboration					
In my own work for GLOBAQUA, I'm strongly oriented towards learning from other disciplines					

10. Please indicate to what extent you agree with all of the following statements about the interdisciplinary research orientation of other participants in GLOBAQUA.

Interdisciplinary orientation in GLOBAQUA (other participants)	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
The other participants in GLOBAQUA recognize the added value of my discipline					
The other participants in GLOBAQUA recognize the expertise from my discipline					
The other participants in GLOBAQUA are open to learn from my discipline					
GLOBAQUA members as a group are open-minded about considering research perspectives from fields other than their own					

11. Please indicate to what extent you agree with the following statements on the interaction/ interdisciplinarity in GLOBAQUA.

Degree of interactive research in GLOBAQUA	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
In GLOBAQUA there is a lot of interaction between different disciplines					
In GLOBAQUA much time is spend on understanding other disciplines					
In GLOBAQUA research methods from different disciplines are integrated					
In GLOBAQUA theories and models from different disciplines are integrated					

12. Please indicate to what extent you agree with the following statements on the degree of understanding between different disciplines that has been achieved in GLOBAQUA up till now

Degree of integrative understanding in GLOBAQUA	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree

Up till now, GLOBAQUA helped in developing a common understanding between the disciplines					
Up till now, GLOBAQUA helped in developing shared concepts between the disciplines					
Up till now, GLOBAQUA helped in developing a shared framework between the disciplines					

13. Please indicate to what extent you agree with the following statements about the atmosphere during the general assembly meeting in Athens

Atmosphere during the General Assembly in Athene	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
The atmosphere during the meeting has been comfortable					
The other participants were willing to listen to my contributions					
There was enough time for discussing ideas with other team members					
The meeting helped me to get to know the other participants better					
I feel comfortable to show limits or gaps in my knowledge to the other participants					

14. Please indicate to what extent you agree with the following statements about the extent in which GLOBAQUA has contributed to interdisciplinary learning

Effectiveness of GLOBAQUA in advancing understanding	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
I think that interdisciplinary research among GLOBAQUA participants will lead to valuable scientific outcomes for river based management that would not have occurred without collaboration					
Generally speaking, I believe that the benefits of interdisciplinary research within GLOBAQUA outweigh the inconveniences and costs of such work					
GLOBAQUA helped me to learn from other disciplines					
GLOBAQUA has improved my understanding of other disciplines					
GLOBAQUA has improved my appreciation of other disciplines					
GLOBAQUA has improved my integrative understanding of water issues					

15. Please indicate to what extent you agree with the following statements about the challenges in collaboration between different disciplines in GLOBAQUA

Challenges	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
Conflicts between disciplinary perspectives on river based management are frequent in GLOBAQUA					
There is a high level of competition among the disciplinary groups in GLOBAQUA					
Collaboration between different disciplines has posed a significant time burden in my research for GLOBAQUA					
Up till now, collaboration between different disciplines in GLOBAQUA has not been productive					

16. What are to your opinion the main challenges in the cooperation between different disciplines in GLOBAQUA so far?

17. What have you learned from the collaboration with other disciplines in GLOBAQUA so far?

Annex 2

Annex 2. Globaqua Module meeting survey questionnaire

Questionnaire 2: Knowledge integration during the Module meeting

Introduction to the survey

Dear participant of the GLOBAQUA research project,

In the next pages you will find a questionnaire by which we will follow the progress of knowledge integration in GLOBAQUA. This monitoring of knowledge integration is part of the activities of WP 12 and will provide the overall project management, WP-leaders and module leaders feedback information on the progress of the integration process during the lifetime of the project.

The questionnaire will take about 10 minutes to fill in. Respondents will stay anonymous.

For more information about the survey, you can contact Adriaan Slob [adriaan.slob@tno.nl] or Tara Geerdink [tara.geerdink@tno.nl]

Questions to track the data

Explanation

The following questions are used to track the data in time. Respondents stay anonymous, only the questionnaires themselves are coded in order to follow the data! We will ask you to provide the first letter of your father's and mother's name. Together with the year of birth we are able to code the questionnaire.

1. What is the first letter of your father's first name? Please circle one of the letters below

A—B—C—D—E—F—G—H—I—J—K—L—M—N—O—P—Q—R—S—T—U—V—W—X—Y—Z

2. What is the first letter of your mother's first name? Please circle one of the letters below

A—B—C—D—E—F—G—H—I—J—K—L—M—N—O—P—Q—R—S—T—U—V—W—X—Y—Z

3. What is your year of birth? (Only the last two numbers: 1978 = 78)

General control questions

4. What is your sex?

Male

Female

5. What is your disciplinary background? Please tick one category: choose the disciplinary category in which you are mostly educated.

Physical sciences (includes hydrology, physics, earth sciences, chemistry)

Life sciences (includes biology, genetics, medical sciences)

Environmental sciences

Engineering

Social sciences (includes economics, sociology, political science, psychology)

Humanities (includes philosophy, history, arts)

Other, please specify

6. How many years of experience do you have in <u>interdisciplinary</u> research projects?

….. year(s).

7. In which module are you most actively involved?

Module 1

Module 2

Module 3

Module 4

Module 5

8. In which work package(s) are you mainly participating? (Multiple answers possible)

WP 1	WP 8
WP 2	WP 9
WP 3	WP 10
WP 4	WP 11
WP 5	WP 12
WP 6	WP 13
WP 7	WP 14

9. Please indicate to what extent you agree with the following statements about the atmosphere during the (module) meeting.

Atmosphere during the (module) meeting	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
The atmosphere during the meeting has been comfortable					
The other participants were willing to listen to my contributions					
There was enough time for discussing ideas with other team members					

The meeting helped me to get to know the other participants better					
I feel comfortable to show limits or gaps in my knowledge to the other participants					

10. Please indicate to what extent you agree with the following statements on the interaction/ interdisciplinarity in this (module) meeting.

Degree of interactive research in this module for GLOBAQUA	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
In this (module) meeting there is a lot of interaction between different disciplines					
In this (module) meeting much time is spend on understanding other disciplines					

11. Please indicate to what extent you agree with the following statements on the interaction/ interdisciplinarity in this module.

Degree of interactive research in this module for GLOBAQUA	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
In this module research methods from different disciplines are integrated					
In this module theories and models from different disciplines are integrated					

12. Please indicate to what extent you agree with the following statements on the degree of understanding between different disciplines that has been achieved during this (module) meeting

Degree of integrative understanding in (module) meeting	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
This (module) meeting helped in developing a common understanding between the disciplines					
This (module) meeting helped in developing shared concepts between the disciplines					
This (module) meeting helped in developing a shared framework between the disciplines					

13. a. Did differences in research perspectives come to the fore during this (module) meeting? Please elaborate how

13. b Please indicate to what extent you agree with the following statements on discussing differences in research perspectives during this (module) meeting

Discussion of differences in disciplinary research perspectives	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
Differences in disciplinary research perspectives among module participations became clear during the meeting					
Differences in disciplinary research perspectives among module participations were discussed during the meeting					
Differences in disciplinary research perspectives among module participations were dealt with during the meeting					

14. Please indicate to what extent you agree with the following statements on the management of knowledge issues during this (module) meeting

Management of (module) meeting	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
The module manager(s) listens to the inputs of the different disciplines					
The module manager makes sure that every discipline get enough room for having their say					
The module manager has a feeling for the different disciplines involved					
The module manager respects the different disciplines involved					
The module manager is focused on building an informal atmosphere among participants					
The module manager is focused on stimulating interaction between the different disciplines					
The module manager is focused on building trust among participants					

15. Please indicate to what extent you agree with the following statements on the management of knowledge issues during this (module) meeting

Management of structural tasks in this module	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
The module manager stimulates interaction across work packages within the module					
The module manager sets deadlines					
The module manager stimulates information exchange among participants					

The module manager coordinates the different inputs and deliverables of the work packages					

16. Please indicate to what extent you agree with the following statements on the management of knowledge issues during this (module) meeting

Management of knowledge integration in this module	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
The module manager is focused on visioning					
The module manager addresses the need for knowledge integration across different disciplinary boundaries					
The module manager is focused on aligning participant's individual scientific aspirations with the GLOBAQUA mission					
The module manager challenges participants to cross their disciplinary boundaries					

17. Please indicate to what extent you agree with the following statements about the extent in which this (module) meeting has contributed to interdisciplinary learning

Effectiveness of module in advancing understanding	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
I think that interdisciplinary research among module participants will lead to valuable scientific outcomes for river based management that would not have occurred without collaboration					
Generally speaking, I believe that the benefits of interdisciplinary research within this module outweigh the inconveniences and costs of such work					
This (module) meeting helped me to learn from other disciplines					
This (module) meeting has improved my understanding of other disciplines					
This (module) meeting has improved my appreciation of other disciplines					
This (module) meeting has improved my integrative understanding of water issues					

18. Please indicate to what extent you agree with the following statements about the challenges in collaboration between different disciplines in this module

Challenges	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree

Conflicts between disciplinary perspectives on river based management are frequent in this module					
There is a high level of competition among the disciplinary groups in this module					
Collaboration between different disciplines has posed a significant time burden in my research for this module					
Up till now, collaboration between different disciplines in this module has not been productive					

19. Do you think this (module) meeting helped in making progress in this research project? Please elaborate why.

20. On a scale from 1 to 10, how would you rate this (module) meeting? Please elaborate why

1	2	3	4	5	6	7	8	9	10

21. Please indicate to what extent you interact with other work packages in GLOBAQUA

How often do you exchange information and knowledge with	Never	Occasionally, but less than once a month	Once or twice a month	Once or twice a week	About once a day
People from work package 1					
People from work package 2					
People from work package 3					
People from work package 4					
People from work package 5					
People from work package 6					
People from work package 7					
People from work package 8					
People from work package 9					
People from work package 10					
People from work package 11					

People from work package 12					
People from work package 13					
People from work package 14					

22. How much time did you need to fill in this questionnaire?

Annex 3

Annex 3. Globaqua Sampling campaign survey questionnaire

Questionnaire 3: Knowledge integration during the Sampling campaign

Introduction to the survey

Dear participant of the GLOBAQUA research project,

In the next pages you will find a questionnaire by which we will follow the progress of knowledge integration in GLOBAQUA. This monitoring of knowledge integration is part of the activities of WP 12 and will provide the overall project management, WP-leaders and module leaders feedback information on the progress of the integration process during the lifetime of the project.

The questionnaire will take about 5 minutes to fill in. Respondents will stay anonymous.

For more information about the survey, you can contact Adriaan Slob [adriaan.slob@tno.nl] or Tara Geerdink [tara.geerdink@tno.nl]

Questions to track the data

Explanation

The following questions are used to track the data in time. Respondents stay anonymous, only the questionnaires themselves are coded in order to follow the data! We will ask you to provide the first letter of your father's and mother's name. Together with the year of birth we are able to code the questionnaire.

1. What is the first letter of your father's first name? Please circle one of the letters below

A—B—C—D—E—F—G—H—I—J—K—L—M—N—O—P—Q—R—S—T—U—V—W—X—Y—Z

2. What is the first letter of your mother's first name? Please circle one of the letters below

A—B—C—D—E—F—G—H—I—J—K—L—M—N—O—P—Q—R—S—T—U—V—W—X—Y—Z

3. What is your year of birth? (Only the last two numbers: 1978 = 78)

General control questions

4. What is your sex?

Male

Female

5. What is your disciplinary background? Please tick one category: choose the disciplinary category in which you are mostly educated.

Physical sciences (includes hydrology, physics, earth sciences, chemistry)

Life sciences (includes biology, genetics, medical sciences)

Environmental sciences

Engineering

Social sciences (includes economics, sociology, political science, psychology)

Humanities (includes philosophy, history, arts)

Other, please specify

6. How many years of experience do you have in <u>interdisciplinary</u> research projects?

….. year(s).

7. In which module are you most actively involved? Module 1

Module 2

Module 3

Module 4

Module 5

8. In which work package(s) are you mainly participating? (Multiple answers possible)

WP 1

WP 2

WP 3

WP 4

WP 5

WP 6

WP 7

WP 8

WP 9

WP 10

WP 11

WP 12

WP 13

WP 14

9. Please indicate to what extent you agree with the following statements about the atmosphere during the sampling campaign.

Atmosphere during the sampling campaign	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
The atmosphere during the sampling campaign has been comfortable					
The other participants were willing to listen to my contributions					
There was enough time for discussing ideas with other team members					
The sampling campaign helped me to get to know the other participants better					

I feel comfortable to show limits or gaps in my knowledge to the other participants					

10. Please indicate to what extent you agree with the following statements on the interaction/ interdisciplinarity in this sampling campaign.

Degree of interactive research in this sampling campaign for GLOBAQUA	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
In this sampling campaign research methods from different disciplines are integrated					
In this sampling campaign theories and models from different disciplines are integrated					

11. Please indicate to what extent you agree with the following statements on the degree of understanding between different disciplines that has been achieved during this sampling campaign

Degree of integrative understanding in sampling campaign	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
This sampling campaign helped in developing a common understanding between the disciplines					
This sampling campaign helped in developing shared concepts between the disciplines					
This helped in developing a shared framework for the sampling campaigns.					

12. a. Did differences in research perspectives come to the fore during this sampling campaign? Please elaborate how

12. b. Please indicate to what extent you agree with the following statements on discussing differences in research perspectives during this sampling campaign

Discussion of differences in disciplinary research perspectives	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
Differences in disciplinary research perspectives became clear during the sampling campaign					
Differences in disciplinary research perspectives were discussed during the sampling campaign					
Differences in disciplinary research perspectives were dealt with during the sampling campaign					

13. Please indicate to what extent you agree with the following statements about the extent in which this sampling campaign has contributed to interdisciplinary learning

Effectiveness of this sampling campaign in advancing understanding	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
This sampling campaign helped me to learn from other disciplines					
This sampling campaign has improved my understanding of other disciplines					
This sampling campaign has improved my appreciation of other disciplines					
This sampling campaign has improved my integrative understanding of water issues					

14. Please indicate to what extent you agree with the following statements about the challenges in collaboration between different disciplines in this sampling campaign

Challenges	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
Conflicts between disciplinary perspectives on river based management are frequent in this sampling campaign					
There is a high level of competition among the disciplinary groups in this sampling campaign					
Collaboration between different disciplines has posed a significant time burden in this sampling campaign					
Up till now, collaboration between different disciplines in this sampling campaign has not been productive					

15. Do you think this sampling campaign helped in making progress in this research project? Please, elaborate why.

16. On a scale from 1 to 10, how would you rate this sampling campaign? Please, elaborate why.

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Annex 4

Annex 4. Semi-structured interview questionnaire with Globaqua Module and work package leaders

Semi-structured interview questionnaire: Module and work package leaders

Interview on a progress of interdisciplinary collaboration in Globaqua

I. Opening/basic questions

1. What is your educational disciplinary background?

2. Did you have interdisciplinary work experience prior to Globaqua?

II. Interdisciplinary collaboration and related challenges

3. Generally, how do you perceive the interaction between different disciplines? In your opinion, how the process of interaction between disciplines should look like?

4. To be more specific, could you describe the interaction between different disciplines, or between the researchers with different disciplinary backgrounds, in Globaqua? Please, elaborate on the interaction within your Module X, and/or within the WP-X.

5. Could you describe, how the official meetings in Globaqua are organized? And how each of them contributes to enhancing interdisciplinary collaboration between the project partners from different work packages and Modules? Please, be specific about General Assemblies, Module meetings, and Sampling Campaigns.

6. What informal joint activities you have in Globaqua that are not necessarily related to the work in the project? And how they contribute to both group performance, and the relationship between the scientists in the project? If possible, give concrete examples.

7. With regard to interdisciplinary collaboration, what significant challenges you see in Globaqua? Also, how to tackle them, and what do you do as a Module and/or work package leader in order to deal with them?

III. Organisation of work, and communication between project partners

8. Speaking about the organisation of work in Globaqua, I would like you to elaborate on how you organise work within your Module X. In particular, how you organise the meetings and the flow of communication between the work packages and different partners you work with?

9. Speaking about your WP-X, what specific task(s) it has in the project? And what is your role as a Module and/or work package leader in ensuring the task(s) is completed?

10. What kind of joint activities and/or moments of contact facilitate interdisciplinary collaboration with colleagues that you have to work with the most? If possible, give some concrete examples.

IV. Scientific knowledge integration, and a progress of interdisciplinarity

11. Could you describe in your own words, how you perceive interdisciplinarity?

12. Do you see a progress of interdisciplinarity in Globaqua, compared between the early stage of the project and now? Please, elaborate in the context of your WP-X, Module X, or overall in Globaqua. And if yes, how can you observe that interdisciplinarity is progressing?

13. Has the learning between the disciplines been achieved either in your Module, or in other Modules so far? If yes, could you be more specific in describing 'interdisciplinary learning'?

14. Speaking about the main objective of Globaqua – could you define it in your own words, and say whether or not it will be achieved in two years-time?

15. Given the fact that Globaqua is interdisciplinary project, does it have an advantage compared to mono- or multidisciplinary projects? If yes, what in particular?

V. Collaborative team learning behaviour: short questions

16. How would you describe the current atmosphere in your Module X, or overall in Globaqua?

17. Building upon the previous question, would you say that various conflicts (if any) among the researchers are being solved constructively?

18. Would you say there is a certain level of trust among Globaqua participants? If yes, how could you explain the development of trust among the researchers in your own Module? Please, elaborate.

19. Do you see any evolution of the relationship between the participants either in your Module, or in Globaqua in general since the beginning of the project? If yes, please, elaborate.

VI. Factors and conditions influencing interdisciplinary collaboration

20. Speaking about personalities of individuals, what characteristics make a scientist an easy-to-collaborate colleague? If possible, give examples from Globaqua.

21. With regard to professional disciplinary characteristics of individuals, do they have a specific impact on one's behaviour and/or performance in Globaqua? If possible, give concrete examples.

22. In your opinion, is the overall organizational setting, set in the description of work of Globaqua, facilitating interdisciplinary collaboration? If yes, how in particular? And if no, what should be done differently?

23. What is your overall opinion of participating in Globaqua, and when looking in to the future of the project?