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Sönke Graf

«We're better, connected»

Empirical study on the potential of international science teacher trainings

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Empirical study on the potential of international science teacher trainings

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I would like to dedicate this thesis to my loving parents and to my saviour . . .

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A dissertation is not written in a day or two, it turns into somewhat of a longtime companion, escorting you through several seasons of your life. So from the first ideas to the final printout a dissertation is likely to also meet several different versions of yourself, in very different stages. Just like some drafts of your dissertation are not very good and contain errors and need a serious rewrite, some versions of you are not very endearing, making terrible errors and also hurting people. And just as you have to let go of some great parts in your dissertation, that are containing some unique and good thoughts, some people have to let you go, because they have found, that despite seeing something good in you, they also see too many things that would require so much rewriting, that it is best to open a new file.

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Although this acknowledgement may sound somewhat saddening to some readers (Sorry!), alas it is not: Because as you are coming closer to the final draft, you are not feeling sorry for the pages lost, but for the form attained and just as the version you pick up from the bookbinder is a version you like, all the pages in your life that you make the effort to seriously rewrite, will make you a better person in the end: Not a version free of errors, yet a version with less errors. Not a version finished, yet a version to build upon.

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ZUSAMMENFASSUNG

Anhand einer internationalen Naturwissenschaftslehrerfortbildung zum Computergestützten Arbeiten im naturwissenschaftlichen Unterricht (CAT) konzentriert sich diese Arbeit auf eine tiefere Analyse der informellen Kommunikationsprozesse zwischen Teilnehmer/innen gleichwie auch Fortbildner/innen, außerhalb formaler Fortbildungssitzungen.

Die internationale Naturwissenschaftslehrerfortbildung war als „Blended Learning"-Kurs mit zwei Onlinephasen und – dazwischen – einer Präsenzwoche mit Vorlesungen, Seminaren und Workshops konzipiert worden. Während dieser Woche wurden Kommunikationsprozesse einvernehmlich, während informeller Gespräche[1] zwischen Teilnehmern/innen (und Fortbilder/innen) von den Teilnehmer/innen selbst aufgezeichnet. Die informellen Unterhaltungen wurden transkribiert und anhand der Themen mithilfe einer Qualitativen Inhaltsanalyse (induktive Variante) nach Mayring [2010, S. 67 und 83ff.] kodiert. Die Themen wurden nach Häufigkeit ihres Auftretens in Bezug auf Zeit, Ort und Situation analysiert. Algorithmisch wurden Kommunikationspartner auf Grundlage eines vereinfachten Kommunikationsmodells, welches sich für „big-data" anbot, ermittelt. Auf diese Weise konnte eine Matrix von Kommunikationspartnern erstellt und für Netzwerkvisualisierung und Analysen genutzt werden. Die Datenlage legt nahe, dass die Kommunikation von situativen Aspekten abhängt und dass Naturwissenschaftslehrkräfte rund ein Viertel der aufgezeichneten Gespräche in informellen Räumen dazu nutzten, ihre persönliche berufliche Situation zu reflektieren. Das informelle Gesprächsnetzwerk ist ein verbundenes Netzwerk, welches sich gegenüber Muttersprache und Alter sozial homophil verhielt. Professionelle

[1] Die Teilnehmer waren darüber aufgeklärt, dass die Aufnahmen nicht Teil der Fortbildung waren, dass jeder Teilnehmer einer Unterhaltung jederzeit das Recht hatte, die Aufnahme zu stoppen zu lassen, und dass Aufzeichnungen das Einverständnis aller Anwesenden benötigten. Sie wurden darüber informiert, dass die Unterhaltungen transkribiert und nur in anonymisierter Form einem geschlossenen Kreis an Personen für wissenschaftliche Zwecke zugänglich gemacht werden. Sie wurden abschließend gefragt, ob sie der Selbstaufnahme unter besagten Bedingungen zustimmen würden. Alle Teilnehmer stimmten zu.

Unterhaltungen ergaben sich insbesondere in den Morgenzeiten und nahmen über den Tag hinweg ab. Soziale Aspekte schienen im Tagesverlauf an Bedeutung zu gewinnen.

TALIS-Daten (Teacher and Learning International Survey) wurden verwendet, um ein umfassenderes Verständnis von Naturwissenschaftslehrkräften und ihren Arbeitsbedingungen zu erhalten. Sie erlauben ebenfalls Einblicke in die Wirkungen von weiterbildungsrelevanten Aspekten der Bildungspolitik (z.B. Unterstützung von Weiterbildungsmaßnahmen).

Die aus den Feldbeobachtungen und aus TALIS gewonnen Erkenntnisse wurden genutzt, um in benachbarten Feldern nach brauchbaren Konzepten zu suchen, welche sich bei der Entwicklung umfassender Weiterbildungskonzepte als nutzbringend erweisen könnten. Soziologische Konzepte wie das self-contained classroom (SCC)[2], das Autonomie-Paritäts-Prinzip (APP) und die Idee von lose gekoppelten Systemen (loosely coupled systems) legen nahe, dass die Lehrkraft verstärkt unter Einbeziehung ihrer Unterrichtspraxis angesprochen werden sollte, um eine Integration der Lehrerfortbildungsinhalte zu begünstigen. Die soziologische Idee der Stärke der schwachen Bindungen legt nahe, dass entfernte Knotenpunkte eines Netzwerkes (beispielsweise die Teilnehmer einer internationalen Naturwissenschaftslehrerfortbildung) wertvolle Informationen füreinander bereithalten und daher miteinander ins Gespräch gebracht werden sollten. Psychologische Modelle wie das *„career choice model"* und das *„career stage model"* sind hilfreich, die grundlegenden Persönlichkeitstypen von (Naturwissenschafts-) Lehrkräften zu verstehen und dabei zu helfen, auch die „sozialen", „investigativen" und „geschäftstüchtigen" (career choice model) Aspekte in eine Naturwissenschaftslehrerfortbildung zu integrieren und auch die beruflichen Phasen (career stage model), welche ein Lehrer in seinem Berufsleben typischerweise durchschreitet, schon in der Gestaltungsphase einer Lehrerfortbildung zu berücksichtigen.

Die Dissertation bringt alle untersuchten Themen miteinander ins Gespräch, um neue Pfade für die berufliche Weiterbildung auszuloten.

[2] In etwa „das autarke Klassenzimmer".

Abstract

Inside the science teacher training on Computer Aided Teaching (CAT) teacher training, research of this dissertation was focussed on an in-depth analysis of informal communication processes between participants as well as trainers, that occurred outside the formal session times. The international science teacher training had been designed in a blended-learning structure with two online phases and – in between – one face-to-face week, including lectures, seminars and workshops.

The communication processes analysed were consentaneously recorded by the participants themselves in informal conversations[3] between participants (and trainers). The informal conversations were transcribed and coded according to the topics informally addressed by means of a Qualitative Content Analysis (inductive form) [Mayring, 2010, p. 67 and 83ff.]. The topics were analysed in terms of occurrence according to time, location and situation. Algorithmically filtering out communication partners based on a simplified communication model suited for algorithmic "big-data"-analyses a matrix of communication partners could be constructed and was used for network visualisation and analyses. Data indicated that informal communication was influenced by situational aspects, that science teachers spend around a quarter of the recorded conversations reflecting on their personal professional situation in the informal spaces of the training. The informal conversation network indicated a connected network that showed signs of homophily with regards to mother tongue and age. Professional conversations ranked high in the mornings and decreased over the day. Social aspects seemed to increase over the day.

[3]The participants had been informed that the recordings were not part of their training, that everyone participating in the conversation could always ask to stop recording, and that recordings were only allowed when everyone involved granted permission. They were given the information that the recordings would be transcribed yet the transcriptions were only published in anonymised form and only for scientific purposes in a closed circle. They were finally asked whether they would agree to the self-recording on said terms. All participants agreed.

TALIS (Teacher and Learning International Survey) data was used to get more comprehensive understanding of the science teacher population and their working conditions. It also provided insight on the effects on PD relevant educational policies (e.g. PD support).

The understanding gathered from the field data, as well as from TALIS was used to look for useful concepts in neighbouring fields that may prove useful in terms of developing broader PD concepts and providing useful. Sociological concepts like the self-contained classroom (SCC), the autonomy parity pattern (APP) and the idea of loosely coupled systems are suggesting that teachers increasingly should be addressed by referring to their practice, in order to aid the integration of teacher training content. The sociological idea of the strength of weak ties suggests that remote nodes of a network (e.g. the participants of an international science teacher training) may hold valuable information for each other and should be brought into communication. Psychological models like the career choice model and the career stage model help to understand the basic personality types of (science) teachers and thus help to integrate the social, investigating and enterprising aspects (career choice model) of a science teacher training concept and to somewhat take into account the professional phases a teacher typically goes through in his or her professional life (career stage model) already in the design phase of a science teacher training.

The dissertation brings all investigated matters in touch with each other in order to explore new paths for professional development (PD).

PRELIMINARY REMARKS

Before the reader is introduced into the work the author would like to take the time to notify of some specialities with regards to this work.

First of all, the work was written in the British English (BE) language. As the contents of the work are dealing with an international science teacher training and the field of research concerned with professional development itself is international the English language was chosen in order to allow for an easier international reception of the work.
Despite giving his best in order to deliver a reading experience that is free of mistakes it has to be clearly stated, that the author is not a native speaker of English.

In the thesis also, German literature is being used and cited. In order for international readers to be able to understand the contexts important citations from German research were translated by the author into the English language. These translations were executed with great care, without any omissions and to the best of my abilities. In case the reader finds any of the translations to be incorrect or misleading, the author kindly asks for notification.

In this thesis pronouns are often used in the first-person plural. The reader is kindly asked not to understand this as a violation of section 7 subsection 2 (e) of the Regulations for the Doctoral Degree Procedures at the Pädagogische Hochschule Heidelberg – University of Education Heidelberg in which I correctly and truthfully declared that this thesis is *"an independent achievement solely accomplished by me"*.

The first-person plural in this thesis is meant in one of the following ways: Either it refers to the author and includes the broader research community[4]or the first-person plural is regarded as a tribute to all the people, that took part in

[4]As in "...we essentially find professionalization in up to four different professional stages..."

the teacher training course CAT, to all colleagues that discussed my project at conferences and in multiple sessions inside doctoral colloquia at my university. Although I have pursued these studies independently, this thesis could not have been written without the “we” of a lot of people. In writing my thesis I finally decided not to ignore the slightly awkward feeling whenever I was using the first-person singular but to replace it with a first-person plural instead. The use of the first-person plural of course does neither mean, that this work represents the opinion of any of these people nor that they necessarily condone the methods and/or conclusions and/or results I describe in this work.

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CHAPTER 1

DESIDERATUM FOR RESEARCH

In improving science education every stakeholder in educational policy as well as every educational scientist or every educational practitioner is faced with the same question always: Where do I start?

Obviously, this question is a highly complex one and one that prima facie defies simple answers. Still – to begin this rather bold and overly complex enterprise of improving science education with this provokingly simple question proves to be a good starting point nonetheless. Let us presume that the question "Where do I start" in most cases has an ulterior motive and, in those cases, could be replaced with the question: "Which measures give me a maximum yield in positive effects, with as little systemic or personal investment effort or cost?"

Surprisingly educational research does provide us with some beneficial research regarding this question of an efficient starting-point: Several studies [e.g. Hattie, 2009; Mourshed et al., 2010] pinpoint the teacher as having a significant effect either on student learning and/or achievement. Studies by Konstantopoulos [2005] and Luyten and Snijders [1996] show, that in terms of student achievement the role of the teacher outweighs the role of the school and the circumstances teachers and students are working in. Comparative studies on teacher effectiveness even suggest, that students taught by high-performing teachers progress three times as fast as those placed with low performing teachers [Barber and Mourshed, 2007, p. 12]. Rivkin et al. could show, that the reduction of class size by ten students produced smaller benefits than the improvement of one standard deviation in teacher quality [Rivkin et al., 2005, p. 419]. Stressing the importance of (science) teachers for student achievement has even become a focal point of strategy advice to policy makers by the OECD:

"Teachers are important because of their impact on student learning. The research indicates that raising teacher quality is perhaps the policy direction most likely to lead to substantial gains in school performance" [McKenzie et al., 2005, p. 23]

Apparently, there is some agreement towards the notion that improving science teacher effectiveness might be one appropriate way to increase student performance (also in science). Of course, the consequential question follows swiftly: "How do I improve science teacher effectiveness? (And where do I start here?)"

This question too is highly complex in nature and opens a plethora of viable options, ways, sub questions and possible answers. However, it can be addressed in quite a comparable manner as the first question, by approaching it in sensible ways. When looking at all the occasions in which science teachers currently professionalize, we essentially find professionalization[1] in up to four different professional stages (in chronological order):

1. Socialization as science pupil
2. Professionalization as pre-service science teacher[2]
3. Professionalization as science teacher on probation (induction programmes)[3]
4. Professionalization as science teacher

Figure 1.1 shows the stages of professional development in a teacher's professional life. The longest stages or phases usually will be the stages one and four. It is only reasonable to assume that the longest stages quite considerably contribute to a teacher's shaping. It is also essential to note, that stage four and one are entangled in a fateful manner: It is primarily the teachers in stage four that through their teaching examples already give shape to the next generation of teachers (namely the science pupils in stage one). Also stage four teachers bear some relevance in the training of teachers in stage three: Stage three in Europe is implemented mostly by means of a formal induction programme including mentoring in schools with experienced stage-four-teachers, regular meetings, assistance or advice about lesson planning and job shadowing; it can often include course modules, seminars or workshops at initial teacher education institutions [Caena, 2014, p. 8].

[1] In terms of his socialisation and professional training.

[2] Which according to Caena [2014, p. 8] in Europe is mostly acquired through a four- or five-year university degree.

[3] Caena [2014, p. 8] reports this is to be the case in 17 European countries.
Often this phase is also associated with some degree of "praxis shock" or "reality shock" [Smagorinsky et al., 2004; Bromme and Tillema, 1995, p. 261; Rolls and Helle, 2009, p. 12].

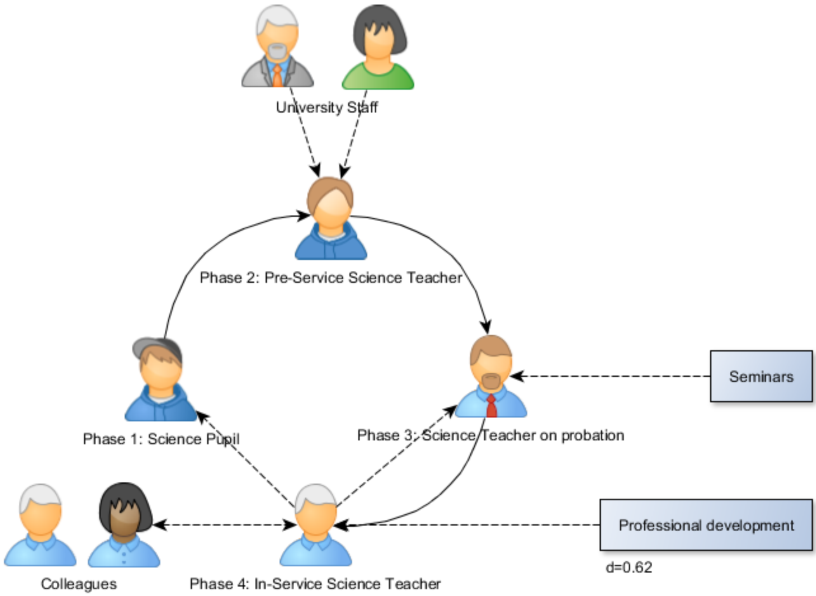


Figure 1.1 Teaching and Professional Development Cycle

Influencing and shaping the teaching of in-service science teachers (stage 4) in a positive and sustainable manner does not only contribute to the pupil's achievements but must be counted as a long-term investment in the next generation of science teachers also. Finally, teachers from stage four for the duration of their work life quite likely will have an effect on their stage four and their stage three colleagues.

In terms of learning processes stage four additionally could provide a pedagogical advantage over phase 1 and phase 2: Workplace learning – in-service teachers (stage four) can rather quickly test the knowledge/competencies/skills gained in a training in their own classrooms. This close connection between professional development (PD) content and practice – in theory allows for additional reflection and discussion of experiences with colleagues and teacher training course maintainers. Additionally in-service teachers can engage in methods like Action Research [Altrichter et al., 2008] and/or cognitive apprenticeship [Brandt et al., 1993] which help to keep the teacher training course's content in use.

Regarding our initial question we have reason to believe that the professional development of in-service science teachers may be a sensible starting point. Looking at the results of Hattie's influential yet also somewhat controversial meta study "Visible Learning" - professional development is attributed an effect size of d=0.62[4] altogether, Hattie differentiates between different outcomes for professional development activities

1. Reaction – how the teachers felt about the professional development (d=0.42)

2. Learning – the amount of learning the teachers accrued (d=0.90)

3. Behaviour – whether teachers changed their teaching behaviour as a result of the professional development (d=0.60)

4. Student outcomes – impact on student learning (d=0.37) [Hattie, 2009, pp.119-121]

In our line of reasoning and our attempt to find a good starting point for an intervention improving science education the rather medium effect of teacher professional development on student learning (d=0.37) could be a negative indicator. However, we must not let ourselves be set on the wrong track in this matter: Generalized effect sizes in the area such as diverse and complex as professional development need to be seen very critically. There is no "standard" PD activity

[4]Professional development thus fulfils Hattie's criteria for the "zone of desired effects" ranging from d=0.4 upwards.

which could be described by one effect size: Professional development activities are simply far too diverse in their nature; they range from literature studies over teacher trainings in PK, CK and PCK to PCLs/PDNs (professional learning communities/professional development networks), observation visits to other schools, individual and collaborative research, mentoring and peer observation to informal dialogues with colleagues.

It is true that the main activities teachers partake in are focused on mainly three activities (see page 5) – yet in the professional development field of courses and workshops alone[5] – the concepts, duration, sequencing, methods, trainers and contents are much too diverse to "lump" them together under one effect size. The wide range of courses available in fields like subject-specific teaching, learning theory, educational psychology, sociology, assessment, measurement and testing, classroom management [list of courses taken from McKenzie et al., 2005, p.100] also make it hard to clearly understand the general effect courses and workshops might or might not have on student learning.

We take Hattie's results as a cause for a much closer look at the complex issue that is PD and as a reason to form ideas on how an effective professional development of in-service teachers might positively influence the professionalization cycle of teachers described above.

Looking at what empirical educational science knows about the way in-service teachers professionalize we need to take a look at data provided by the *Teaching and Learning International Survey* (TALIS). [OECD, 2009, 2010, 2014a,c,d, 2016]. As we are focussing on science teacher PD we will also extract unpublished data from the TALIS databases specifically addressing the situation of science teachers (also see chapter 2). A first look at the TALIS data reveals that teachers essentially resort to three professionalization activities:

1. Informal dialogues with peers on how to improve teaching

2. Courses/workshops

3. Reading professional literature

[cf. OECD, 2009, p. 57; OECD, 2010, Table 3.2; OECD, 2014b, p.103 Table 4.8]

Since these PD activities are the ones most frequently used and the only ones that more than 50 percent of the surveyed teachers agreed to have been using – we would like to focus on two of them.

To further the understanding of PD of in-service science teachers we would like to introduce the idea, that the above-mentioned PD activities rarely exist in

[5] Which is one of the most widely used forms of professional development (PD) among teachers.

their pure forms but that most of the times teachers resort to multiple PD activities sometimes even at the same time. It is therefore of great interest not only to look at each PD activity separately but to look at the interactions and possible synergies between different PD activities. This research is crucial in several ways: First, it allows for structuring and planning PD activities with the other PD activities in mind. Secondly a growth in complexity and responsibility of the modern teaching profession have put teachers into the position of having less and less time for traditional stand-alone PD activities [also see Heise, 2009, p. 10; OECD, 2014b, p. 86] – due to a lack of time and organizational bottlenecks modern professional development most likely cannot afford not to look closely at gains in efficiency through synergies between different professional development activities, which could support and possibly amplify each other in terms of efficiency and impact. We deem it a promising idea, to scientifically explore the interconnections and overlaps of the most commonly used forms of teacher professionalization.

Setting foot into the field of contextual professional development requires certain groundwork to be accomplished. It is essential to gather as much data as possible by close observation inside the field. This data then needs to be analysed, reduced, interpreted and reflected carefully [cf. Strauss and Corbin, 1996, pp. 5–7]. This direction marks the trajectory as well as the scope of this work: We would like to scientifically pursue the idea, that two of the most commonly used forms of professional development namely informal dialogues to improve teaching and courses and workshops are deeply interconnected and do coincide within science teacher training courses. It is our aim to take a detailed look on the informal communication between participants of a one work week-long international science teacher training course on the use of Information and Communication Technologies (ICT) and to find out in what way do in-service teachers from different countries use informal communication inside that training course? When do they communicate informally and about what do they communicate? Do certain patterns arise? We also want to see how the communication evolves throughout the course.

The work will take an in-depth empirical look at the informal dialogues that happened inside a five-day exemplary formal science teacher training on Computer aided teaching (CAT) and present the topics that science teachers talked about inside the informal moments of the training. It will also try to look at the development of informal communication between participants. After the thorough analysis of the informal communication inside the course, the work will form well-founded hypotheses based on the field data as well as current educational, sociological, psychological, socio-psychological research to reflect on approaches for course design, that manage to incorporate informal as well as formal aspects of science teacher trainings as well as reflections on relevant factors to PD as a whole

– such as to enhance the efficiency and/or the sustainability of science teacher training courses. It must be stated clearly, that the hypotheses formed within this work cannot be and do not claim to be empiric facts and that conclusions drawn from the informal communication of the teacher training course at hand cannot claim to reach beyond the group of teachers participating in our teacher training. Also we want to make the reader aware of the fact, that the interpretation of the communication of the teachers by applying codes to the informal conversation texts – although done with the utmost care and confirmed through communicative validation by a team of two persons, who coded around 80% of the audio material independently and then came together to discuss several options of coding and interpretation supported by several individuals, familiar with most of the material – is intersubjective at best: The interpretation of the communication data never is an objective procedure as such – we can merely claim to have strived toward a high degree of inter-subjective interpretation (see chapter 7 for more details). The same goes for the conclusions drawn from the data at hand.

This work is a first exploratory step into a fairly new field of professional development research, which hopes to come up with some reasonable hypotheses gained from the combination of current research literature and from deeper analyses of field data, that hopefully serves as an inspiration for further research.

Chapter 2

The field data and the TALIS databases

Next to looking at research results from different disciplines (literature review), the work at hand essentially uses three data sources:

The first data source is field data in the form of transcribed audio data self-recorded by teachers and trainers during informal conversations that took place at an international science teacher training course CAT (Computer Aided Teaching) on the use of ICT in science lessons (see chapter 5) that was conceptualised by a consortium of multiple international partners between 2008 and 2010 and finally offered in the Comenius Teacher Training database in 2011.

The second and third data sources are selected data from two databases that contain results of a representative and international survey across teachers of different, mainly European nations called TALIS (Teacher and Learning International Survey) that is published by the Organisation for Economic Co-operation and Development (OECD) and mainly focuses on the International Standard Classification of Education (ISCED) level 2 (lower secondary) teachers and their working conditions[1]. TALIS sets a minimum sample size of 4000 teachers and 200 school principals per country and thus can be counted. In this chapter we will give you a description of these three essential data pools:

2.1 Field data

The data collection of audio-recording informal communication during a formal science teacher training proves to be a delicate enterprise, since the informal communication is a matter deeply entangled with privacy issues. This is why at

[1] ISCED level 1 (primary school teachers) and ISCED level 3 (upper secondary school teacher) programmes are optionally available.

the beginning of the science teacher training CAT the topic was addressed openly: The purpose of the data collection was made transparent; the propagation of the data was strictly limited to scientific publications on condition of anonymization of the identity of the speakers. The teachers were asked to only record conversations, that everyone who took part, agreed to be recorded. Also, they were invited to openly say, when the recording was not welcomed. Our data collection started inside the face-to-face of the blended learning science teacher training course (CAT) that was dealing with the use of ICT in science classes. As we were focusing on the informal conversations between participants as well as or participants and trainers, we used the introductory session on Monday 28th March 2011 morning to kindly ask the teachers to take five digital audio recorders[2] and to start recording themselves in informal conversations only.[3] The teachers were asked to occasionally switch the recorders among themselves, so that distinct groups were randomly recorded. One recorder remained with the author and was used in the same way. Over the week, the following amount of audio recordings were gathered:

Table 2.1 Recordings of informal conversations

Time of Day	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**All days**
9:00 - 12:00	00:01:24	01:25:20	00:00:00	00:20:39	00:16:58	02:04:21
12:00 - 15:00	00:55:18	03:22:54	02:56:45	01:20:26	00:00:00	08:35:23
15:00 - 18:00	00:00:00	00:22:53	00:15:25	00:00:00	00:02:13	00:40:31
18:00 - 21:00	01:04:37	00:00:00	00:00:00	00:00:00	00:00:00	01:04:37
21:00 - 01:00	05:45:00	01:25:24	00:26:26	06:01:49	00:00:00	13:38:39
Total time:	**7:46:19 h**	**6:36:31 h**	**3:38:36 h**	**7:42:54 h**	**0:19:11 h**	**26:03:31**

2.1.1 Reflections on the data structure

Analysing the table more closely and comparing it to the schedule of the face-to-face week (see table 5.1 on page 97) there are some observations to be made. The majority of recordings fall into two time-slots: lunchtime (which was scheduled between 12:00 – 14:00 - see table 5.1) and late evening (21:00 – 01:00). This suggests several different interpretations:

As instructed the teachers did not make recordings during the work sessions but mostly recorded the informal slots of the day. The fact, that most of the

[2] All recording devices were Olympus DM-450 all preset to Rec Mode: ST HQ, MP3: 256kbps, Mic Sense: High, Low Cut Filter: On, Zoom Mic: Wide. The clock on all devices was also pre-adjusted to Greek local time. For further details see manual at http://download.aws.olympus.eu/consumer/manuals/audio/DM-550_DM-450_MANUAL_EN.pdf.

[3] This meant no recording of conversations during the formal course work, aiming primarily at recordings in informal setting.

recordings occurred in the latest evening time-slot and not in the time-slot from 18:00 o'clock – 21:00 o'clock could either be accounted to the difficulty of making recordings during activities.[4] Or it could also merely point to a certain preference of our course participants to informally connect in the later evening (compare Monday, Thursday) after a downtime of sorts.[5]

Allowing this interpretation could mean, that after a hard day's work our participants needed some time for themselves before coming together and connecting later in the evening. This however without taking a closer look at the data itself is rather speculative.

It is important to reflect, that the occurrences of informal conversations and times of recording do not (necessarily) overlap. It remains unknown, whether the time slots marked by less recordings truly are time slots with significantly less informal conversations or whether these conversations remained for some reason or other unrecorded.[6] Due to the busy schedule of the face-to-face training the times of recordings must also not be regarded as teacher's time specific preference for informal conversations but rather a use of the open slots in general. The way the data was generated must be critically reflected in the formation of all hypotheses. However, while hypotheses about time-slots with less recordings should be treated with the utmost scientific care and require detailed methodological treatment – it is perfectly reasonable to use the data for time-slots in which communication data is abundant, in order to carefully derive hypotheses.

The data often containing multiple speakers and also from time to time containing multiple parallel conversations was transcribed and then coded inside MAXQDA 10. For a detailed description of the Methodology see chapter 7.

2.2 TALIS 2008 / 2013 databases

This work also makes use of the data gathered by the Teacher and Learning International Surveys (TALIS) commissioned by the Organisation for Economic Co-operation and Development (OECD). The TALIS survey consists of two questionnaires, a principal questionnaire and a teacher questionnaire, primarily directed at lower secondary teachers (ISCED level 2), although optional surveys for primary school teachers (ISCED level 1) and upper secondary teachers (ISCED level 3) are provided also. The survey has a sample size of a minimum of 4000 teachers per country coming from a minimum of 200 schools. The surveys also contain questions regarding the professional development (PD) of teachers.

[4] It might have been difficult to make recordings in situations of people walking about or being absorbed by cultural activities – like on Tuesday or Wednesday.

[5] See transcript of R5450028 paragraph 7.

[6] This could be for practical reasons or due to lack of motivation or due to distraction.

The first round of TALIS took place in 2007/08 and surveyed over 70.000 teachers in over 4000 schools in 23 countries. The second round of TALIS took place in 2013[7] have been published and includes data from more than 170.000 teachers in over 10.000 schools in 33 countries and economies. The survey included an additional Mathematics Teacher Module.

As official publications on TALIS results do mostly refer to descriptions of the whole teaching population [OECD, 2010, 2014a,b,c], we were unable to find published data regarding individual subsets of teachers – like for instance science teachers. The OECD however did publish the databases and the full surveys for download [8] thus allowing researchers to extract desired subsets from the complete databases. The subset BTGINTT1 of the TALIS 2008 database includes all international data from the teacher survey regarding ISCED Level 2 (lower secondary education). The subset BTGINTT2 of the TALIS 2013 database includes all international data from the teacher survey referring to ISCED Level 2 (lower secondary education) in round two of TALIS. Both teacher surveys (TALIS 2008/TALIS 2013) contain questions regarding the teachers' subjects. In TALIS 2008 question 33 asks:

"We would like to ask you about the main <ISCED Level 2> subjects that you teach in this school in this school year."

and provides the option c:

"Science
Includes science, physics, physical science, chemistry, biology, human biology, environmental science, agriculture/horticulture/forestry."

In TALIS 2013 question 15 asks:

"During this current school year, do you teach the subjects below to any [<ISCED Level X> / 15-year-old] students in this school?"

and provides the option c:

[7] At the time of publication first datasets called volume 1 of the third round that took place in 2018 have been published on http://www.oecd.org/education/talis/talis-2018-data.htm some of the results are used in this publication to present the reader with the latest results. However, volume 1 does not yet allow for the results to be related to science teachers specifically.

[8] TALIS 2008 data and surveys: https://stats.oecd.org/Index.aspx?DataSetCode=TALIS (accessed 09/17/2017); TALIS 2013 data and surveys: https://stats.oecd.org/Index.aspx?DataSetCode=TALIS_2013 (accessed 09/17/2017).

"Science"

In the TALIS 2008 and TALIS 2013 databases the item determining the teachers' status as active science teacher in lower secondary education have the variable name: BTG33C (TALIS 2008) and TT2G15C (TALIS 2013) and are described by the following typologies (see tables 2.2 and 2.3):

Table 2.2 Typology of variable BTG33C in TALIS 2008 databank marking active science teachers

Var. No.	Question	Variable Name	Variable Label	Code	Option	Location/Format
156	TQ-33C	BTG33C	PRACT /MAINSUB /SCIENCE	1 2 9 8	Yes No Omitted Not admin. VLD: BTG33C $'1#2#9#8' Flags: SCR: 156 /CAR:F /CAT:B /DEF:	177 /C 1.0

Table 2.3 Typology of variable TT2G15C in TALIS 2013 databank marking active science teachers

TALIS 2013 typology for TT2G15C:
Label Background/ Subjects taught in current school year/ Science Type Integer Level Nominal Width/Decimals 1.0 Columns 874-874 Range ValueScheme 1: Yes (1) / No (2) 1 Yes 2 No MissingScheme 1: Background missing scheme (numeric) .R / 7 Not reached .A / 8 Not administered . / 9 Omitted or Invalid

The software PSPP[9] was used to access the databases and the commands (see table 2.4):

Table 2.4 PSPP Commands to extract science teacher population from TALIS 2008 and TALIS 2013 databases

TALIS 2008 database (BTGINTT1) Command:	TALIS 2013 database (BTGINTT2) Command:
SORT CASES BY BTG33C. SPLIT FILE SEPARATE BY BTG33C.	SORT CASES BY TT2G15C. SPLIT FILE SEPARATE BY TT2G15C.

were used to extract the science teacher population from the original dataset. Then the Frequencies procedure was used to generate frequency tables of several variables of the TALIS 2008/TALIS 2013 science teacher datasets. The results of these descriptive frequency analyses provide a specific view on lower secondary science teachers and have been used throughout this work. Whenever data from TALIS had to be extracted using the databases it was noted in the description of the respective table or figure as:
"Source: Own extraction from TALIS [year] database".

[9]Version: GNU pspp 1.0.1-g818227 See: https://www.gnu.org/software/pspp/

Chapter 3

Current research on teachers and teacher training

Before we delve into the research questions and the methodology we will take a closer look at the current level of research in the field of the (science) teacher profession in general (chapter 3) and in the field of teacher training in particular (chapter 4).
The research presented in both chapters constitute the findings regarding research questions 3 (a) and 3 (b). They mark the results of intensive literature studies (see page 107 in chapter 6). An introduction into the methodology of this research question is given in section 7.3 (see page 155).

A (science) teacher training is well advised to try to figure out more about the target of a (science) teacher training – to better understand the needs and specifics of their clients. In the business world, this is referred to as customer analysis. Understanding the (science) teaching profession from within for us seems to be a viable and a possibly essential step in finding suitable and sustainable strategies for the implementation of teacher trainings. In this chapter, we will present selected data as well as research on the teaching profession. It is important to understand, that portraying all available research results on the teaching profession would go far beyond the scope of this work. We had to focus on the most promising sources in terms of relevance to the area of science teacher training design: After intensive absorption and careful reflection, we decided to present the reader with a variety of selected data and research that we believe to have strong practical implications for the design of teacher trainings.

3.1 Vocational personalities and work environments

Since 1959 Holland has been developing his theory of career choices [Holland, 1997] that produced an empirically reproducible typology of vocational personalities and work environments. The theory has been described as one of the most influential theories explaining vocational behaviour in general and combining personal as well as contextual variables [Leung, 2008; Nauta, 2010; Savickas and Gottfredson, 1999].

The Oxford Handbook of Counselling describes the practical impact of the theory by stating:

"The types[1] are measured with a myriad of well-known assessment tools, such as the 2005 Strong Interest Inventory [Donnay et al., 2005]" [Oxf, 2011, p. 132].

Holland proclaims, that certain vocational preferences and interests are expression of a (vocational) personality. Holland's idea was, that certain professions were attractive to certain groups of people with specific mindsets and/or skills and that once those people entered said profession the specific common mindset of those people would be a shaping factor in the working culture of the profession.

Nauta explains the reason for Holland's theory having such an impact on work counselling psychology through the high relevance: The congruence of personality type and work environment type

"is theorized to be a determinant of several important outcomes, including job satisfaction, stability, and performance" [Nauta, 2010, p.11].

In his theory Holland defined six empirically determined vocational personalities that claim validity for the western cultures: realistic (R), investigative (I), artistic (A), social (S), enterprising (E) and conventional (C). According to Holland, with this RIASEC typology every person can be assigned to one of these vocational personalities and most of the time can also claim proximity to some of the other personalities. According to Holland's theory vocational personalities are steadily formed through permanent two-way interactions of person and culture (i.e. through genetics, upbringing, family, friends, social strata etc.). According to the theory the permanency of these interactions leads to the manifestation of a set of specific competences and dispositions, which are likely to take influences on certain behaviours or choices. According to Holland's findings this leads to certain professional domains being predominantly occupied by people exhibiting a certain spectrum of mindsets. By testing for typical characteristics, a plethora of patterns deemed typical for a certain profession can arise. These profiles then can be ordered into groups of vocational personalities and looking at the three most common spectra among a certain profession be described by a three-letter

[1] Referring to the RIASEC typology described further down the page.

code that shows the main occurrences of vocational personalities inside of a professional group.

Holland suggested a register of professions and attributed Teacher Elementary School, Teacher Secondary School and Teacher Preschool with the same code: S-A-E suggesting that teachers share a dominating social orientation, with accompanying artistic and enterprising qualities. This set of vocational personalities has since been empirically confirmed in multiple studies [see Abel, 1997, 2008; Eder, 2008; Foerster, 2008].

Before we start introducing the characteristics associated with the vocational personalities – social, artistic and economic according to Holland – it is important to note, that the types of vocational personalities must not be regarded as statements about individual persons but have to be understood as archetypes that are only descriptive of the group as a whole. Regarding the types Holland states:

“A type is a model against which we can measure the real person” [Holland, 1997, p.2].

Using the types as models it is also clear, that the attributes belonging to either vocational personality type (S, A or E) are not necessarily all valid in one person at the same time – as some of them are mutually exclusive: The code S-A-E defines a spectrum of characteristics within which individual teachers might have some likelihood of being. This also explains, how some of the vocational personalities' characteristics attributed to teachers subsumed under the SAE code end up being somewhat contradictory in nature.

The following paragraphs will grant the reader a brief introduction into the three empirical determined personality archetypes used by Holland to describe teachers – ranked in the order of empirical likelihood. And into two additional personality archetypes that Kaub et al. [2012, p. 241] in their study on pre-service teachers studying natural science subjects found to be deviating from Holland's empirical results:

Social

The social type is referred to by Holland as having a preference for activities that have an informing, educational, illuminating or healing character. Their strength (as a group) lies in interpersonal relationships and in the educational field. The social type is less proficient in marked-off, systematic activities or in working with tools or machines. It is described as lacking regarding manual and technical activities [cf. Holland, 1997, p. 24].

Artistic

The artistic type is described as preferring open unstructured activities, allowing for interactions with material, language or people that aim at artistic selffulfilment or creation of products. Like the social type they are deemed less proficient in marked-off, systematic activities [cf. Holland, 1997, p. 23]. According to Holland people of this vocational personality (as a group) are apt to develop skills in some of the fields of language, art, music, drama or writing. As a group, they are less skilled in mathematics or in business practices. They prefer professions in which they can act out their skills – as a group they avoid conventional professions. They value aesthetic experiences, success and self-expression. They acknowledge equality, and personal character traits like courage and phantasy. They are associated with creative ideas and pursue liberal and open goals and values [cf. Holland, 1997, p. 24].

Enterprising

Holland describes the enterprising type as preferring activities or situations in which they can influence, lead or manipulate others in order to reach specific goals. These likings lead to the acquisition of leadership skills and a certain persuasiveness [cf. Holland, 1997, p. 25]. In others, they value ambition and opportunities to influence other people. According to Holland's theory they detest leniency and helpfulness [cf. Holland, 1997, p. 26]. The enterprising vocational personality is described as less proficient in symbolic or systematic activities.

Investigative

The investigative type is associated with scientific, analytic and problem-solving character traits [cf. Oxf, 2011, p. 132]. They are associated with thinking and observing as well as with understanding and organizing. They are also associated with preferring individual activities over people-oriented activities [cf. Holland, 1997].

Realistic

The realistic type is described as mechanical, practical, working with ones hands and being outdoors [cf. Oxf, 2011, p. 132]. They are described as being assertive and competitive. They are thought of men and women of action, that prefer concrete approaches to solving problems rather than theoretical abstractions. Interests include scientific and mechanical fields rather than cultural and aesthetic areas [cf. Holland, 1997].

3.1.1 Vocational personalities and science teaching

In general, these descriptions seem to be very fitting for teachers as a group. Looking at the characteristics more closely it is notable that the codes S, A and E all include traits that are not at all considered beneficial to the job of a science teacher: All three vocational personalities at hand are said to be unsuited for systematic activities, additionally the social personality is described as unskilled in the use of tools or machines and described as lacking in manual or technical activities – the artistic personality is described as less skilled in mathematics. All these attributes that empirically can be attributed to the vast group of teachers seem to be somewhat unfitting for the group of science teachers. Since science teachers are taught to set up experiments, taught to use tools of measurement and also using machines quite expertly and also being trained in the use of mathematics it is a reasonable assumption that the code S-A-E vocational might not be suitable to describe all types of teachers equally. Abel as well as Kaub et al. looked at vocational personalities according to fields of study and found a different distribution for pre-service science teachers. Both found slightly different codes for pre-service teachers of different subjects [Abel, 1997; Kaub et al., 2012]. In Kaub's study the group of science teachers showed significant deviations from the S-A-E. The study also revealed significant effects between teachers of different subjects in the fields: reasoning, spatial sense and perceptual speed.[2] The studies of Kaub et al. and Abel show that there is empirical evidence suggesting that pre-service science teachers might be somewhat different to the averaged pre-service teacher cohort described by the traditional S-A-E coding. In Kaub's cohort results showed (see table 3.1) that the group of teachers that studied natural sciences only, are more accurately described by the code S-I-E (social, investigative, enterprising). Compared to the vocational personality of the average teacher student, science teacher students are considerably higher associated with the realistic and the investigative fields while being much less associated with the artistic field. With the exception of the enterprising domain, mixed type pre-service teachers[3] on the other hand find themselves somewhat in between the vocational personalities of the average pre-service teacher profile of Kaub's cohort and the vocational personality of the pre-service teachers studying natural sciences only. Regarding the personality fields investigative, realistic and social however the mixed-type teachers lean much more towards the average of the cohort.

[2] Students of sports related subjects were reported to have advantages over students of other subjects in said domains.

[3] Pre-service teachers studying subjects from natural sciences and humanities or languages.

Table 3.1 Means (and standard deviations) according to combination of subjects for the vocational personality types. Excluded is the conventional type. Source: Excerpt from Table 2 of [Kaub et al., 2012, p. 241]

teaching post	pr and sd	realistic	investigative	artistic	social	enterprising
natural sciences	*percentage rating*	**29.32**	**34.39**	26.55	**34.84**	**31.76**
	standard deviation	8.26	5.37	7.28	6.73	7.30
mixed types	*percentage rating*	23.02	29.22	**31.39**	**37.56**	**33.11**
	standard deviation	6.94	6.38	7.00	6.52	5.48
all teaching posts	*percentage rating*	23.14	28.24	**33.09**	**38.35**	**33.58**
	standard deviation	7.21	6.95	8.25	6.15	6.03
theor. min./max.		10/50	10/50	10/50	10/50	10/50

Though the study by Kaub et al. is well designed and executed with the utmost care the number of pre-service science teachers surveyed is small[4] and further study in this field is much needed. Still the results empirically support the idea, that science teachers might be a somewhat different group inside the group of the average teachers and the results might even suggest a division inside the group of science teachers itself – namely between the science teachers that only teach natural sciences and the ones teaching in humanities and/or languages also. The view on the teaching profession through the eyes of Holland's theories of vocational personalities is a promising one in order to better understand the target group of science teacher trainings. Even though the evidence needs further scientific exploration and as of yet has to be regarded as uncertain – it may already act as a beneficial perspective for the development of training courses nonetheless.

3.1.2 Relevance of career choice theory for PD

The vocational personality may act as basis for the general attitude and interests of the science teacher training group at hand. Reflecting on the research results by Holland and Kaub as well as others [also see Abel, 1997, 2008; Eder, 2008; Foerster, 2008; Holland, 1997; Kaub et al., 2012; Rothland, 2014] it might prove beneficial to include the RIASEC typology into the conceptual development of a

[4] N for pre-service teachers studying natural science=38/mixed types=54/all pre-service teachers=227.

course early on. According to research by Kaub it may even be beneficial to know whether or not the participants are teaching natural sciences only (implying a more S-I-E oriented profile) or whether they are teaching humanities or languages as well (meaning a more S-A-E oriented profile).

Interestingly enough some implications of the vocational theories' S-A-E (or S-I-E)-Coding of science teachers' traits – possibly without being realized as such –have come into the focus of research about teacher learning in the last decade: Lipowsky states that more and more constructivist learning theories have been used to explain teacher trainings [Lipowsky, 2014, p. 511]. According to Lipowsky the regress on constructivist learning theories is due to the modern perception of learning as occurring amidst or rather through social exchange, that has to sensibly connect with existing cognitive structures (e.g. previous knowledge) (ibid.). This remark strongly bears the insignia of vocational personalities. Comparing the following citation of Ball & Cohen as well as Rank et al. found in [Lipowsky, 2014, p. 511] [5] containing the personality description of S-A-E we are finding astonishing similarities:

"The confrontation with different ideas, perceptions and opinions and the experience of dissonances have come to be ascribed a certain meaning regarding the extension of knowledge, the questioning of one's own practice and regarding the change of classroom practice (Ball & Cohen, 1999). Recourse to approaches of situated learning, the general assumption is that (further) trainings for teachers should be oriented at teachers' daily experiences, trying to be complex and authentic, meaning emanating from everyday situations of practice (Rank, Gebauer, Hartinger & Fölling-Albers, 2012; Reuser, 2005)"[Lipowsky, 2014, p. 511]

The description of the dominant codes S-A-E confirm the approach suggested by Rank et al. – the strong social stance in teachers makes many of them strive for interaction and exchange. The artistic code also supports the idea of many teachers liking the exchange of creative and new ideas. The code enterprising also affirms a preference for discussion and persuasion as well as possibly a general or specific acknowledgement of their professional accomplishments. In a way previously unthought of, aiming for constructivist ways of learning inside a (science) teacher training course, that is oriented at *"teachers' daily experiences"* (ibid.) also means to be oriented towards the vocational personality that is at play in everyday school life.

For the conception of the training these aspects might contain a blueprint for possible vectors of approach regarding the transfer of teacher training content.

[5] Autor's translation.

Conceptual development of science teacher training courses could actively reflect on appropriate exercises and methods for imparting the content based on the knowledge and research on vocational personalities.

As well as career choice theories, sociological studies on the teaching profession, next to delivering a very useful systemic understanding of school as we will later see in section 3.5, are also a source contributing to knowledge about the target group that may help developers of science teacher trainings to shed light on the general mindset and important conditions of the working environment that need to be reflected. Lortie for example found several potent attractors to the teaching profession. One attractor he labelled "The Theme of Time Compatibility": The fact, that the teaching profession features "convenient gaps" like school holidays or work days finished mid-afternoon is attractive to people who for some reason or other require or value a certain flexibility regarding their scheduled work times [Lortie, 2002, p.31f]. This might help explain the fact that time came up twice in the ranking of impediments to participation in teacher trainings (see table 4.1).

3.2 Age structure of science teacher labour force

Due to the digital revolution, the age structure of the workforce quite possibly has implications for science teaching as well as for the development of concepts for in-service teacher trainings – this goes especially for science teacher trainings that involve ICT related topics (see chapter 5). For the development of a training this may have very serious implications. Due to several official OECD statistics we can get a good overview. The TALIS 2013 database even allows us to compare the age distribution of science teachers to the age distribution of the rest of the surveyed cohort:

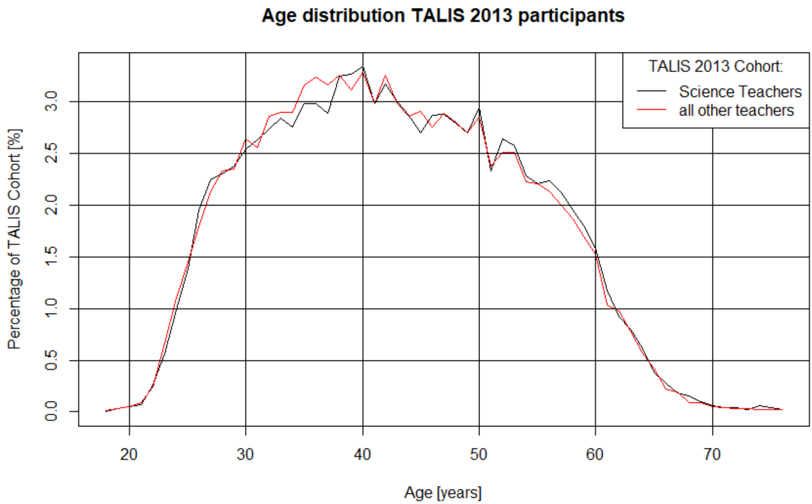


Figure 3.1 Age distribution of TALIS 2013 participants. Source: Extraction from TALIS 2013 database

The statistical mean and standard deviation of the data can be seen here:

Table 3.2 TALIS 2013 – Teacher Age distribution Statistics

	Science teachers	All other teachers
Mean	42,84	42,6
Standard deviation	10,74	10,64
Minimum	19	18
Maximum	76	76

The age distribution between the TALIS 2013 science teacher sample and all other teachers of the sample seems to be in a fairly good alignment for the most part of the distribution and provides us with some idea about the state of the age distribution for science teaching. Taking a look at the official statistics of the OECD a certain development regarding the age-distribution can be adumbrated. Here is the age-distribution from 2005–2015 within the EU22[6] in (lower) sec-

[6]The EU22 refers to countries being members of the EU and the OECD. These were at the time of being surveyed Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany,

ondary education. Please note that the numbers for the year 2010 are EU19[7] and include secondary and post-secondary, non-tertiary education.

Table 3.3 Development of teacher's age 2005–2015. Compiled from the official OECD teacherstatistics. Years 2005 and 2015 are EU22 and refer to lower secondary education. Year 2010 is EU19 and includes secondary and post-secondary, non-tertiary education. Source:[OECD, 2017, p. 398, OECD, 2013, p. 404]

	OECD 2005 EU22	OECD 2010 EU19	OECD 2015 EU22
Aged less than 30 [%]	13	9,27	9
Aged 30-49 [%]	56	54,23	54
Aged 50 or older [%]	31	36,5	37

As can be seen, there seems to be a stronger negative development in the EU in the age group below 30 years of age. In the age group between 30 and 49 years of age there also seems to be a slightly negative development. The age group older than 50 years of age however seems to be growing in a considerable manner. As the statistics for 2010 are including the upper secondary and post-secondary education, it is not exactly clear whether or not the trend has slowed down between the years 2010 and 2015 or whether the included upper-secondary and post-secondary numbers somewhat obfuscate the development for the lower secondary education.[8] The development inside the TALIS sample between the rounds in 2008 and 2013 seem to confirm a drop in the percentage in the age group of under 30 years old, which marked a sharper decline for the subgroup of science teachers than it did for the entirety of the sample:

Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, the Netherlands, Poland, Portugal, Slovenia, the Slovak Republic, Spain, Sweden and the United Kingdom.

[7] Data missing from Denmark, Greece and Latvia.

[8] Reliable EU wide developments are hard to gather as several member states did not contribute numbers to the OECD statistics every year. As can be seen from direct queries at http://stats.oecd.org/

Table 3.4 Age distribution between the TALIS 2008 and 2013 rounds. Source: TALIS 2008 and 2013 databases

	TALIS 2008		TALIS 2013	
	All teachers	science teachers	All teachers	science teachers
Aged less than 30 [%]	13,69	14,19	12,23	12,23
Aged 30-49 [%]	58,68	58,8	59,03	58,18
Aged 50 or older [%]	27,63	27,01	28,77	29,58

In the age group 30 to 49 the TALIS sample showed a small growth, while the subgroup of science teachers showed a small decline between the rounds. The age group of teachers aged 50 years or older showed a small growth for the total sample while showing a much larger growth for the subgroup of science teachers. Despite being representative the data at hand is yet too scarce to be conclusive. It remains to be seen whether or not European science teaching possibly more than other faculties has to deal with a slowly overageing labour force.

3.2.1 Relevance of age distribution for PD

The age of participants as well as the amount of years on the profession constitute both important factors affecting science teacher trainings. In 1989 Huberman already had described a teacher career stage model and had introduced the several phases that teachers go through within their career [Huberman et al., 1993; Huberman, 1989]. The model by Huberman according to Richter et al. [Richter et al., 2011, p. 117] is widely accepted, and is being used time and again to interpret results from empirical studies. It is only natural, that each of these career phases comes with very different requirements and PD-needs.

The early years

Richter et al. report that inside the U.S. Schools and Staffing Survey (SASS) – results showed *"... that beginning teachers (1-3 years of experience participated more frequently than any other group of public school teachers in mentoring or peer observation (50,7% over the 12-month period surveyed). They also showed high attendance of formal activities such as conferences and workshops (93,3%) and continued to attend university courses in their main teaching subject (31,5%)... "* [Richter et al., 2011, p. 118]

In terms of content that was interesting to teachers in the early phases of their career:

"... beginning teachers attended more activities targeting classroom management and student discipline than did experienced teachers (more than 3 years of experience)." (ibid.)

The career entry according to Huberman [1989] (see figure 3.2) is associated with mixed feelings due to a reality shock - there is a:

"[...] lack of self-confidence or a feeling of inadequacy. On the other hand, precisely these challenges and the opportunity to utilize the training they have received lead to an eagerness to learn and develop as a teacher"
[Rolls and Helle, 2009, p. 12]

In line with Huberman's description of the "eagerness to learn and develop as a teacher" and the SASS findings cited by Richter et al. [2011, p. 118], teachers were found to have a high level of commitment to the profession within their first three years of teaching [cf. Rolls and Helle, 2009, p. 12].

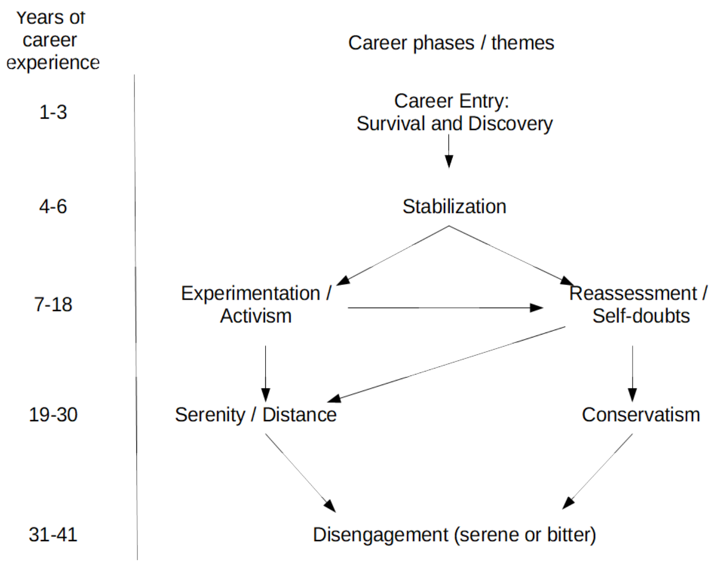


Figure 3.2 Career stage model according to Huberman [1989]

The way that teachers in this phase find ways to overcome the lack of self-confidence and manage to address challenges seems to find representation in a different senses of efficacy: In a 4-year mixed methods research project including 300 elementary and secondary school teachers Day [2007, p. 247] reports that teachers in the first three years either showed a developing sense of efficacy (60%) or a reducing sense of efficacy (40%).

Teachers in this phase face a lot of entirely different and highly complex challenges and tasks, which at the beginning they have to prioritize as they cannot be tackled all at the same time. According to Fessler and Christensen [1992, p. 41] teachers in this phase are mainly focussed on:

"[...] gaining the respect of pupils and colleagues, and becoming comfortable in dealing with everyday classroom practice."

For a teacher training course, the knowledge on the specific characteristics and of typical problems arising inside this phase are highly relevant in terms of finding training content related equivalents, that may help teachers in this phase to overcome practical problems. Rolls and Helle [2009, p. 15] cite a Swedish study by Fransson and Morberg [2001] mentioning typical problems in the first years that have been determined on the basis of exiting empirical research:

1. Compared to experienced teachers, newly qualified teachers find it difficult to adapt lessons plans, whether in terms of content or teaching strategy, when the situation demands it. Among other things this has to do with the fact that they have yet to develop a repertoire for dealing with unpredictable situations.

2. Newly qualified teachers explain the learning difficulties of pupils with reference to these pupils' personal and social circumstances, whereas experienced teachers look for explanations within the specific learning situations, enabling a more solution-oriented approach.

3. Newly qualified teachers are not prepared for many of the challenges that the teaching profession presents, such as problems with regard to classroom management and tackling disciplinary problems.

4. Finally, newly qualified teachers have problems exercising leadership and handling conflicts.

[Fransson and Morberg, 2001, p. 190ff.]

The mid-years

The years 4–7 in a professional teaching career according to Day [2007, p. 247] seem to be a phase of identity and efficacy. In his study teachers in this phase could be grouped according to three key aspects:

1. strong sense of identity, self-efficacy, and effectiveness (49%)

2. sustaining identity, efficacy, and effectiveness (31%)

3. identity, efficacy, and effectiveness at risk (20%)

The years 7–18 according to Huberman's model (see figure 3.2) mark an important turning point. According to Huberman et al. [1993]; Huberman [1989] there are two potential orientations:

1. *Experimentation and activism*

2. *reassessment and self-doubts*.

This classification is corroborated by findings of Day [2007, p. 248], who found 76% of the teachers to have sustained engagement, while 24% showed a detachment or loss of motivation in years 8–15.

The fourth phase according to Huberman (the years 19–30) is marked yet by another turning point (see figure 3.2): Science teachers oriented towards conservatism are tending towards scepticism and often are critical towards innovations. Teachers who in their fourth phase have oriented towards serenity will be likely to have experienced a decline of engagement but might also be susceptible to try something new as part of a group that the teacher training encouraged.

Different from Huberman's model Day [2007, p. 248] identifies a distinct phase in the years 16–23 that is often characterized by

"[...] facing additional demands outside school, making work-life balance a key concern. [...] The risk at this stage was a feeling of career stagnation linked to a lack of support in school and negative perceptions of student behavior."

In this phase Day [2007, p. 248] identifies three subgroups of teachers marked by the following characteristics:

"(a) further career advancement and good results leading to increased motivation/commitment (52%)

(b) sustained motivation, commitment, and effectiveness (34%)

(c) heavy workload/competing tensions/career stagnation leading to decreased motivation, commitment, and effectiveness (14%) [...]"

The final years

Rolls and Helle [2009, p. 22f.] report research "on teachers approaching retirement" to be "sparse". This attributed to the fact, that as teachers in the last phase were already leaving there was little incentive to fund and conduct research into their professional lives. In the years 24–30 Day [2007, p. 249] registered additional challenges to maintain motivation due to *external policies and initiatives* which corresponds to Huberman's phase of conservatism:

"[...] where teachers feel aggrieved at current developments. Ideals for creating a better future are replaced by the impetus to protect the present from degeneration and a harkening back to a perceived golden age." [Rolls and Helle, 2009, p. 23]

Rolls and Helle [2009, p. 23] however, mention that Huberman did not find evidence "that the majority of teachers" became "more conservative and dissatisfied as they get older". Many teachers "remained open, energetic and optimistic." (ibid.) Day however found that the motivation might be dependent on the type of school also:

"While 60% of primary teachers in this phase were judged to have retained a strong sense of motivation, over half the secondary teachers were rated as losing motivation. Teachers in this phase were categorized as either sustaining a strong sense of motivation and commitment (54%); or holding on but losing motivation (46%)." [Day, 2007, p. 249]

The last phase in Huberman's career cycle model is called disengagement and is characterized by a slow withdrawal from the teaching profession. Interestingly according to Richter SASS results found that teachers in the fifth phase (31–41 years of career experience)

"[...] showed increased participation in training activities on the use of computers for instruction and student assessment." [Richter et al., 2011, p. 118]

A teacher training in the area of ICT thus might be very well be confronted with teachers in their phase of "disengagement" and might thus decide to strengthen the connection between teachers in their fifth phase and younger teachers in order to create a fruitful exchange between the two.

In the phase of 31 or more years Day identified a phase of high commitment. Almost two thirds showed high motivation and commitment. Day reports the cause to be attributed to positive teacher-pupil relationships and pupil progress.

"Positive teacher-pupil relationships and pupil progress were the basis of this. Government policy, health issues, and pupil behavior were often perceived as the most negative factors for this group. Teachers in this phase were seen as either maintaining commitment (64%); or 'tired and trapped' (36%)." [Day, 2007, p. 249]

The knowledge on typical career stages may be regarded as a very effective means of classification of participants. A science teacher training course providing material and methods for teachers of the different phases, possibly has a powerful tool in their hands to prepare for different needs of their participants. For a teacher trainer the information on the current career phase and orientations the participant is in can not only provide a helpful insight into the general attitude and needs that a participating teacher currently has towards their profession, it can help to organize ways to actively decrease phase motivated barriers or to put to good use beneficial phase induced motivations.

Age and preferences for PD type and PD content

From analysing the professional development across the teaching career of 1939 German secondary teachers from 198 schools, Richter et al. could show the ways in which age also played a role with regard to the uptake of formal and informal learning opportunities:

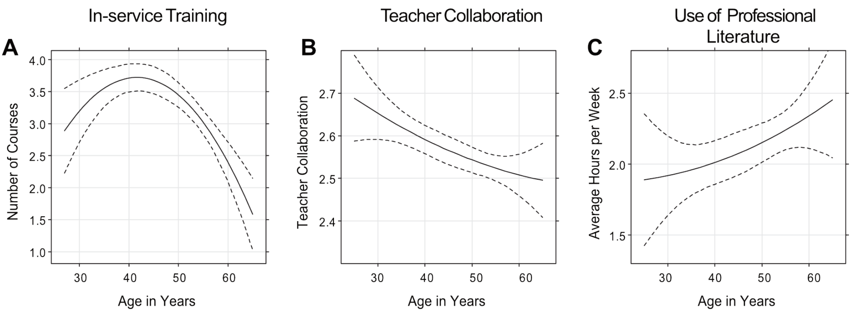


Figure 3.3 Uptake of formal and informal learning opportunities as a function of teachers' age from [Richter et al., 2011, p. 121]

Richter et al. found that: *"[...] teachers' uptake of in-service training across the career was represented by a quadratic function, beginning at a low level at the start of the career, reaching a peak in mid career and decreasing thereafter (...). More specifically, teachers aged 27 participated on average in 2.89 in-service courses in the 2-year period surveyed. The average participation rate increased to 3.72 courses at the age of 42 before decreasing again to 1.58 courses at age 65."* [Richter et al., 2011, p. 120]

Also, the pattern for teacher collaboration was found by Richter to show a negatively linear correlation with age, while the pattern for the "Use of Professional Literature" displayed a positive correlation with age [see Richter et al., 2011, p. 121].

These findings suggest, that in accordance with Huberman's career stages the needs and preferences for different forms of PD are individual for different age groups. For science teacher training development this may result in a mix of formal and informal PD activities to match the preferences of different age groups. The continued interest of stage four and five teachers in ICT may be suitable for blended learning concepts.

Richter et al. also found correlations between age and the general area of content that teacher trainings addressed. Providing a general indicator of what contents are likely to attract teachers relative to their age.

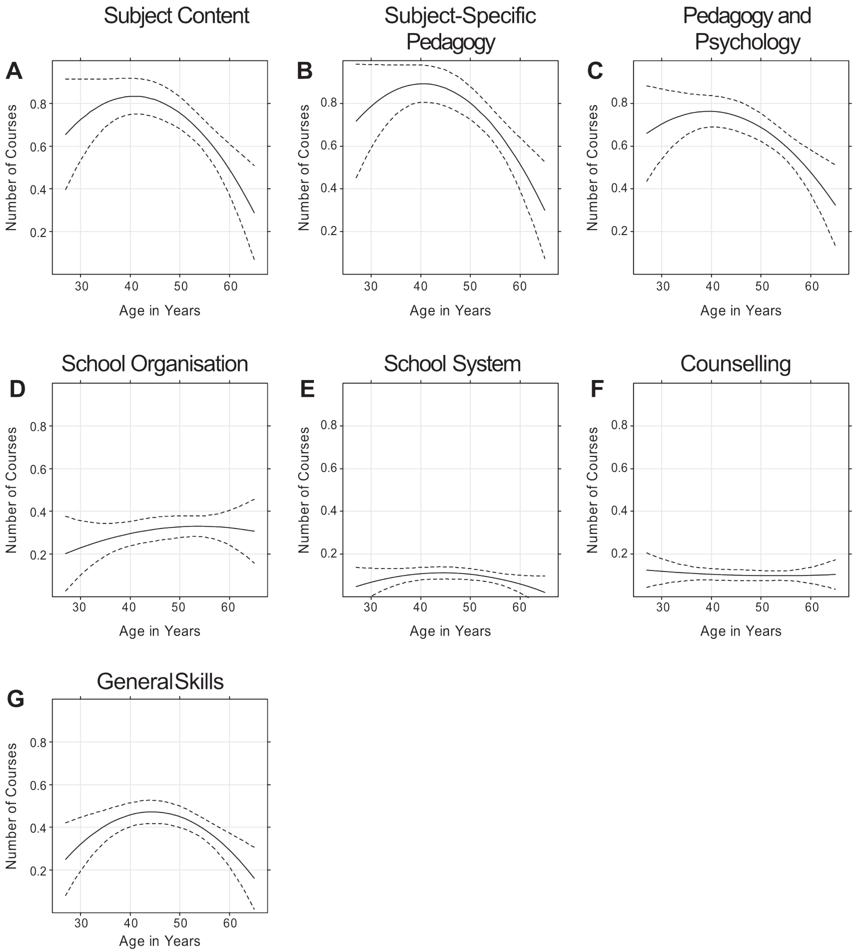


Figure 3.4 Uptake of formal learning opportunities of different categories as a function of teachers' age from [Richter et al., 2011, p. 122]

As can be seen in the data of Richter et al. [2011, p. 122] (see figure 3.4) there are content-specific preferences that for the most popular contents seem to be subject to the general age related trend for training courses seen in Figure 3.3 A. Exceptions seem to occur in teacher training courses on counselling and school organizations, which seems to correlate to a very limited extend (or none at all) with increasing age.

3.3 Science teachers' working hours

Due to TALIS 2013 we have gained a pretty good understanding of what teachers disclose their regular work to be divided into. The survey differentiated between Primary, Lower and Upper secondary teachers. The table on the following page (see table 3.5 on page 34) was created by queries to the TALIS 2013 databank and marks the distribution of hours inside a typical calendar week. It also includes tasks that took place during weekends, evenings or other off-classroom hours.

It is noticeable that after teaching, preparation of lessons, the marking and correcting of student work and general administrative work – the core business of a teacher – the next item on the list is *"Team work and dialogue with colleagues within the school"* with about 3 hours per week for lower secondary science teachers.[9] The self-report of three hours of *"Teamwork and dialogue with colleagues within school"* among science teachers is a vitally important result of the TALIS 2013 survey. Although it is not entirely clear what activities fall under this category [10], it is likely to mostly refer to teacher collaboration and communication, thus constituting an informal PD activity.

Using the TALIS data displayed in the table 3.5 (see page 34) in combination with the official OECD statistics for 2015 [OECD, 2017, p. 381] we can actually calculate a rough estimate of the amount of hours dedicated by lower secondary (science) teachers[11] to *"team work and dialogue taking with colleagues within the school"* per year. The results are presented in table 3.6 (see page 35).

[9] It is quite noteworthy that the 2,6 hours/week reported by lower secondary teachers, matches the average hours/week found by Richter et al. [2011, p. 121] for teacher collaboration at age 42 (constituting the mean of the TALIS cohort).

[10] It does not include administrative communication between teachers, which is explicitly included in "General administrative work".

[11] Assuming that lower sec. science teachers work the same number of week, that the average lower sec. teacher works.

Table 3.5 Average workload of (science) teachers in a regular week. Ranked according to science teachers' workhours. Source: Own extractions of OECD TALIS 2013 Database.

	Primary [h/week]	Lower secondary [h/week]	Upper secondary [h/week]	Lower secondary science teachers [h/week]
Teaching	20,7	19,2	17,6	**20,16**
Individual planning or preparation of lessons either at school or out of school	6	6,2	7,5	**7,59**
Marking/correcting of student work	3	4,1	5,1	**5,15**
General administrative work (including communication, paperwork, and other clerical duties you undertake in your job as a teacher)	2,2	2,2	2,8	**2,99**
Teamwork and dialogue with colleagues within the school	2,9	2,6	2,7	**2,98**
Student counselling (including student supervision, virtual counselling, career guidance and delinquency guidance)	1,6	1,9	2,5	**2,41**
All other tasks	1,5	1,7	1,9	**2,19**
Engaging in extracurricular activities (e.g. sports and cultural activities after school)	1,3	1,4	1,2	**2,05**
Participation in school management	1	1,1	1,3	**1,66**
Communication and co-operation with parents or guardians	1,8	1,6	0,8	**1,62**
Combined/Added up	42	42	43,4	**48,8**

Table 3.6 Estimate of total hours spent by lower secondary (science) teachers for "Teamwork and dialogue with colleagues within the school" per year. Source: Own calculations based on TALIS 2013 database and OECD [2017]

	Lower sec. teachers	Lower sec. science teachers
OECD avg. Teaching	712 h/year	NA
EU22 avg. Teaching	663 h/year	
TALIS 2013 avg. Teaching	19,2 h/week	20,16 h/week
TALIS 2013 avg. Teamwork	2,6 h/week	2,98 h/week
Estimated Teamwork	**90–96 h/year**	**103–111 h/year**

Although the numbers are based on self-reported data and thus should be regarded as an approximation only, the numbers could point to a promising potential for science teachers exchanging ideas and collaboratively investigating new forms of teaching inside of school. This calculation corroborates the already cited TALIS 2008 data teachers inside the TALIS 2008 survey rated *"informal dialogues with peers on how to improve teaching"* as the most preferred and most efficient PD activity (see TALIS 2008 [12] results on page 5 in chapter 1).

3.4 Teacher cooperation as an extension of formal PD

3.4.1 Known forms of teacher cooperation

Since fellow teachers are regarded as a resource for learning and information by their colleagues and since they are in touch with them every week, it is a sensible idea for a formal science teacher training to look at the network of colleagues as a possible extension of the content that it tries to convey. In order to do so it needs to understand the way teachers cooperate in order to find sensible ways to integrate and to connect to. Only by reflecting on the idiosyncrasies of the ways teachers cooperate a sensibly working and also a sustainable connection between the formal and the informal seems possible. By incorporating the peculiarities of teacher cooperation in the design of a comprehensive PD activity early, the fit between PD and the target group of teachers is likely to be increased. A comprehensive overview over research on teacher cooperation pointing to the multiple fields that contributed to the field of teacher cooperation and highlighting the most important steps can be found with Fussangel and Gräsel [2014]. Fussangel and Gräsel differentiate between formal

[12] The item was dropped from the list of PD activities in TALIS 2013.

and informal forms of cooperation taking place in schools, and with regard to the less institutionalized (informal) forms of cooperation state:

> *"[...]they in terms of class- and school development are often the more important forms of cooperation. Also teachers regard the informal initiatives as opposed to formal concepts often as more important for change (Leonard & Leonard, 1999)."*

The following list for the most part is a summary of Fussangel and Gräsel's work, who presented different forms of cooperation in school contexts currently actively discussed [see Fussangel and Gräsel, 2014, pp. 852-854]:

1. Co-operational dyad / peer-coaching
   This refers to low level cooperation in which teachers support each other in preparing lessons, visiting each other within lessons. Usually the "focus lies in the optimization of the students' learning within the subject." [Fussangel and Gräsel, 2014, p. 852] Teachers need a good understanding of each other and reflect their lessons in terms of practice. According to Kreis et al. schools can foster this form of cooperation by giving advanced teachers a training to become coaches [see Kreis et al., 2008]. The close cooperation in tandems is believed by Bauer et al. to be a good starting point for extended forms of cooperation [see Bauer and Kopka, 1996].

2. Faculty internal and faculty comprehensive cooperation
   According to Rolff the faculty plays a special role in terms of cooperation as inside schools they tend to meet regularly in faculty meetings and often developed internal institutionalized structures [see Rolff, 2009]. It is also presumed, that inside the faculty it is easier to agree on common goals for the classes.

3. Cooperation in teacher learning communities
   Study groups are hard to grasp as they can incorporate above mentioned groups and are not defined by a clear set of participants. McLaughlin and Talbert [2006] talk of a teacher learning community as soon as the common aim is to improve one's classes and to support the learning of students in an optimal fashion. The goal is a long-term change in the classroom practice that is achieved by means of a permanent joint reflection.

4. Cooperation in comprehensive co-operations
   Formal co-operations across different schools, that allow teachers to collaborate often also incorporate external professionals that are supporting the

process. Fussangel and Gräsel also mention the avail of a moderator organizing the process across different schools. Fussangel and Gräsel mention the foundation of several teacher learning communities that cooperated with researchers from science and mathematics didactics to develop series of lessons following innovative ideas. Fussangel and Gräsel explicitly mention the bridging function these comprehensive cooperations can possibly fulfil – bridging teacher learning communities and other factors regarding school development.

5. Comprehensive school networks
   Regional networks that span several schools is aimed at developing common goals. Fussangel and Gräsel emphasize the importance of confining the term from the teacher cooperation itself. Comprehensive networks themselves are seen by Fussangel and Gräsel as structural prerequisite for cooperation rather than a cooperation in itself.

3.4.2 Relationship between formal PD and forms of teacher cooperation

The relation between formal forms of PD and formal or informal forms of teacher co-operation according to Fussangel and Gräsel [2014, p. 855] has been reflected predominantly in the in the Anglo-American research literature. Some researchers noted the tension of the different cultures that formal teacher trainings and teacher co-operations had established next to each other: Butler et al. in 2004 reflected on criticism of traditional models of teacher training that made *"false distinctions between formalized and practical knowledge (Bos, 1995; Palincsar et al., 1998)."*

Butler et al. took up Gersten et al.'s and Perry et al.'s critique, that the *"... assumption is that construction of formalized knowledge is the purview of researchers, who then convey new principles to teachers, while teachers' roles are to implement research findings (Gersten et al., 1997; Perry et al., 1999)."* [Butler et al., 2004, p. 437]

This conceptual misunderstanding that used to be widely spread among many actors in educational research has since decreased, however Sumfleth remarks that *"[...] the area of tension between university and practice-oriented needs of the schools is still in large parts lacking established organisational structures even if first approaches are starting to appear.*[13]*"* [Sumfleth, 2017, p. 5]

It seems fair to say that there are still structural deficits that need to be overcome – some of these deficits seem to be heavily interfering with efficiency of

[13] Author's translation.

viable channels of communication between educational research and educational practice:

1. Until fairly recently[14] forms of teacher cooperation existed parallel to formal forms of teacher trainings and were not approached or included into PD concepts or programmes.

2. The practise oriented literature that is preferably read and used by teachers in the field often is despised and discredited by the educational researchers as “unscientific”, while often literature from the field of educational research by practitioners is regarded as “incomprehensible” or “unsuited for the needs of practice” [see Plath, 1998].

The need for transformation of formalized knowledge

The different needs of university and school addressed by Sumfleth [2017, p. 5] and the failures to properly distinguish between *“formalized and practical knowledge”* summarized by Butler et al. [2004, p. 437] and the resulting problems (see above) might point to a common problem that was also addressed by Bromme and Tillema [1995], who by referring to Bunge’s key treatise in the philosophy of science *“Scientific Research – The Search for Truth”*, emphasized, that no theory is transferable into practice without further transformation [Bunge, 2012]. Bromme and Tillema [1995] continued to elaborate their statement and made a crucial point, that we believe marks a crucial starting point for all agents in PD looking for a transfer of educational research into practice:

“Scientific theories, even those stemming from empirical research, are by virtue of their purpose and structure not suited to providing immediate guidance for activity.[. . .] For philosophical reasons (i.e., the philosophy of science), we may be certain that practical knowledge differs substantially in structure and content from theories (as products of research). But what these differences are and where they originate are questions for empirical enquiry. Therefore, they need to be turned over to psychology and other disciplines of cognitive science” [Bromme and Tillema, 1995, p. 262].

It is this difference that requires an investigation into sets of instruments that help to transform knowledge gained in the field of science educational research into practice and gives teachers ways and means to act accordingly. Butler et al. consequentially suggest more collaborative efforts between teachers and researchers:

[14] Also note Sumfleth’s description of the first approaches [Sumfleth, 2017, p. 5].

"[...] both teachers and researchers bring combinations of formalized and practical knowledge to classrooms as they seek to make instructional change. Further, when teachers and researchers collaborate to examine and reflect on practice, both are involved in co-constructing formal and practical knowledge." [Butler et al., 2004, p. 437]

As a common goal for PD Butler notes the following:

"[...] emerging approaches to professional development seek to find the interface, and blur distinctions, between "internal" (practice) and "external" (research) knowledge (Ball, 1995; Bos, 1995; Gersten et al. 1997; Henry et al., 1999; Palincsar et al., 1998; Schumm & Vaughn, 1995)." [Butler et al., 2004, p. 437]

New concepts of formal science teacher trainings (or other forms of formal PD) need to carefully reflect and investigate current forms of teacher cooperation in order to find useful ways of interacting with said forms of PD. It seems necessary for both structures to carefully getting to know each other first and further research in that area is much needed.

3.5 Sociological reflections on teacher behaviour

In creating an interface between theory and practice not only the content to be transferred needs to be reflected but the characteristics of sender and receiver as well as their contexts need to be taken into account. In "profiling" the teacher as the client of PD the sociological dimension[15] is key for an abundance of strategic decisions regarding the implementation of a science teacher training course. The sociological work by Dan Lortie on schoolteachers is a renowned study and the patterns described in his work found international reception as apt sociological descriptions of teachers in the western hemisphere. The study used data, comprising a range of ten years. The methods used include "historical review, national and local surveys, findings from observational studies by other researchers, and content analysis of intensive interviews." [Lortie, 2002, p.xix]. In understanding the teacher's behaviours and attitudes towards teacher cooperation and also towards in-service teacher trainings the sociological dimension provides valuable insights.

[15] It is important for the readers of other fields to grasp that sociology's main focus is the discovery of "patterns of social relationships, social interaction, and culture." [American Sociological Association, 2016] The descriptions of these patterns are results of empiric surveys, interviews and observations often over long periods of time.

3.5.1 The self-contained classroom

The way teachers are trained in academia, according to Lortie is an important factor in their professional socialisation. Lortie could show, that despite giving generally high ratings to the courses received at university more than half (52 percent) of the pre-service teachers missed preparation in fields like applied classroom management, routines, and discipline [Lortie, 2002, p. 68]. Lortie diagnoses “a lack of systematic codification of practical experience” [Lortie, 2002, p. 69] in the typical induction process of schoolteachers. In his sociological analysis he states that educational research (until fairly recently)

“[. . .] has employed models and techniques at some distance from the realities of the classroom”

with the result

“that to an astonishing degree the beginner in teaching must start afresh, largely uninformed about prior solutions and solutions and alternative approaches to recurring practical problems.” [Lortie, 2002, p.70].

In terms of “routine tactical and strategic problems” (ibid.) the pre-service teacher has to learn her/his lessons on the job in a manner of “sink or swim”: Despite a mentor giving advice through briefings for a couple of hours each month, the becoming teacher needs to do a lot of the preparation and teaching work alone by her-/himself. Bromme & Tillema go so far as to diagnose a “reality shock” giving rise to “conservative attitudes” in novice teachers and causing *“[. . .] ambivalent reactions towards the value and usefulness of theoretical knowledge”*[Bromme and Tillema, 1995, p. 261]. According to Lortie, it is this feeling of having to quickly “self-professionalize” adapting to the daily demands of school reality, virtually by oneself – constitutes a socializing moment:

“Such a pattern encourages a conception of teaching as an individualistic rather than a collegial enterprise.” [Lortie, 2002, p. 70].

This may be also be causal to the following – according to Lortie widely distributed – teacher behaviour: Upon assessing how good teachers gauge the effectiveness of their own teaching – 59.1 percent of teachers relied on their own judgement rather than any external source of review or information.[16] Teacher’s holding that view according to Lortie traditionally put themselves in a ‘...gate-keeper’ position over activity in their classrooms.” [Lortie, 2002, p.75ff]. This

[16]Next most frequent choice was “tests and examinations” with 13,5 percent.

view acts like a filter for every "external influence": The teacher's personal judgement decides whether an activity actually is good or bad and thus allowed or denied from reaching the classroom and thus her/his students. To describe this Lortie formed the terminus of the self-contained classroom (SCC) [Lortie, 1972, p. 42]. According to Lortie's study, teachers clearly prefer the help of colleagues (53 percent). Asked for their most important "source of ideas and insight on their work" the teachers mostly picked informal conversations with colleagues (37 percent) and friends from a list including in-service training courses, reading, college courses, meetings in the system and elsewhere and their immediate superior [cf. Lortie, 2002, p.75]. Following the premises of the self-contained classroom teachers also reported that they *"adopted the ideas of peers on a highly selective basis."* [Lortie, 2002, p. 77]. The adopted *"[. . .] practice must be seen as consistent with the receiver's personality and "way of doing things." They portray the diffusion of classroom practices as passing through the screen of the teacher's self-concept – of the way he visualizes his peculiar style of work."* (ibid.).

3.5.2 The autonomy-parity-pattern

In his study Lortie also analysed classical behavioural patterns in teachers. Lortie was the first to describe the autonomy-parity-pattern (APP) as a key expectation of teachers in school:

1. No grown-up should intervene in the lessons of a teacher.
2. Teachers should be seen and treated as equals, and be treated as such.
3. Teachers should be courteous towards each other and not intervene into each other's business.

[Lortie, 1972, p. 42]

That this pattern is different from other organizations, becomes evident when you look at the amount of inspection and evaluation happening in schools compared to other organizations. Too frequent visits of a classroom by the headmaster are frowned upon by the teaching staff and are seen as a threat to professional autonomy. Unsolicited feedback in the same way is often seen as a violation [cf. Weick, 1982, p. 1].
The way teachers are socialised within the autonomy-parity-pattern strongly influences and often limits the ways and means of PD[17] to successfully and

[17] This is especially valid for "external" PD.

sustainably change the classroom behaviour of teachers.
Altrichter and Eder [2004] tried to empirically validate the autonomy-parity-pattern construct and its effects on school development through a survey (n=537) and found that using a 3-cluster-solution roughly 35 percent of the sample could be attributed to the autonomy-parity-pattern, 30 percent were attributed to a group Altrichter & Eder called “lone fighters”, who claimed autonomy, rejected cooperation but did not argue that all teachers should be treated equally but [18] should be treated according to their performance. The remaining 35 percent could be attributed to a group of teachers who were clearly team oriented: They did not claim autonomy, were looking for cooperation and did not think all teachers should be treated equally [Altrichter and Eder, 2004].

3.5.3 Consequences for PD

These sociological descriptions have far reaching consequences for the design of any PD activity. As teachers, according to Lortie’s self-contained classroom principle as well as the autonomy-parity-pattern and Altrichter & Eder’s lone fighter pattern[19], tend to view the implementation of their lessons as a somewhat private matter not to be interfered with offhandedly – from these classic patterns it is obvious that the design of any formal PD activity needs to include provisions and measures to actively respect the autonomy of the teacher. Rather than merely imparting knowledge or instructing the teacher on how to organize her/his lessons, the majority of teachers according to the implications of the self-contained classroom would need to subjectively see and “sympathize” with the benefits of the course contents for his/her own teaching style – so that they can start to develop an intrinsic interest in the contents. Also, the design of the science teacher training according to the autonomy-parity-pattern needs to actively implement a culture that ensures on a level playing field – which to the most possible extent should mark the attitude trainers should adhere to when dealing with course participants.

[18] It needs to be stated that Altrichter & Eder and Lortie might have a misunderstanding here. Lortie in his second point regarding the autonomy-parity-pattern writes, that teachers “should be regarded as equals and be treated as such.” [Lortie, 1972, p.42]. Which to Altrichter & Eder in their development of items validating the construct seems to have meant “all teachers should be treated equally” as becomes clearer in the description of their clusters differing from the autonomy-parity-pattern [Altrichter and Eder, 2004, p. 210]. This however is a slight but relevant shift in meaning.

[19] Together making 65% of the Altrichter & Eder’s total sample.

3.5.4 Loose Coupling

Another important view on teacher cooperation stemming from sociological research, and being relevant to the approaches PD can take – are the ideas around the term "loose coupling" originally formed by R.B. Glassman and later applied to educational organizations by K.E. Weick [see Glassman, 1973; Weick, 1976]. Glassman classifies

"[. . .] the degree of coupling between two systems on the basis of the activity of the variables which the two systems share. To the extent that two systems either have few variables in common or share weak variables, they are independent to each other." [see Weick, 1976, p. 3]

The idea is, that there are different types of organisations: Some organisations are built around and require a strong set of rules; a strong agreement on what the rules are (and how to attain them); a system of inspection and a system of feedback – these organisations are highly standardized and in order to function properly require a tight coupling – every system inside such an organization is dependent on the all the other systems to fulfil certain requirements or to uphold certain standards.[20] Weick by looking at educational organizations found an entirely different structure – the systems were not tightly but loosely coupled – they did not share a lot of variables and were of much greater independence. Upon closer inspection Weick came to the conclusion that *"the task of educating is simply not the kind of task that can be performed in a tightly coupled system"* [Weick, 1982, p. 674].

Looking at the school system it becomes clear, why school is a loosely coupled system: Teaching is a highly individual and highly complex process, that is dependent on many personal characteristics like for instance teaching-personality, organizational preferences and skills, personal beliefs, training and the subjects taught. Each classroom is different and each of them acts as a separate microcosm that in some cases it is hard to find many shared variables. The character traits and beliefs as well as the individual teaching style held by one teacher may vary so much, from the character traits, beliefs and teaching style of a colleague even from the same subject that they are only able to share a very limited set of variables that would mark a tightly coupled system. It is this complexity that makes the transfer of (educational) research knowledge into practice an incredibly complex enterprise that cannot be accomplished without

[20] Think of a firm selling products: The advertising department needs to know about the line products as does the sales department and shipping department. All of the departments need a standardized workflow for the firm to be able to operate.

the active participation and "translation" of each individual teacher. A loosely coupled system according to Weick serves several purposes some of which are:

1. *"Loose coupling lowers the probability that the organization will have to – or be able to – respond to each little change in the environment that occurs"* [Weick, 1976, p. 6].

2. *"[...] a loosely coupled system may be a good system for localized adaption. If all of the elements in a large system are loosely coupled to one another, then any one element can adjust to and modify a local unique contingency without affecting the whole system."* [Weick, 1976, pp. 6–7]

3. *"[...] in loosely coupled systems where the identity, uniqueness, and separateness of elements is preserved, the system potentially can retain a greater number of mutations and novel solutions than would be the case with a tightly coupled system"* [Weick, 1976, p. 7]

4. *"[...] in a loosely coupled system there is more room available for self-determination of the actors. A sense of efficacy might be greater in a loosely coupled system with autonomous units than it would be in a tightly coupled system where discretion is limited."* [Weick, 1976, pp. 7–8]

5. *"[...] a loosely coupled system should be relatively inexpensive to run because it takes time and money to coordinate people."* [Weick, 1976, p. 8]

As so many facets of science teaching are highly dependent on personality and character traits of the teacher and since no "one and only"-standard model of science teaching has been found as of yet, it is only reasonable for the educational organization (e.g. schools) to have systems (for instance science teachers and their classrooms) loosely coupled with each other or the administration. Through the diversity provided by loosely coupled systems with science teachers each having a slightly different take and focus on the curriculum and its significance for the future of the pupil the institution as a whole is less likely to trap itself by having all science teachers teach the same topics in the same way and thus setting all bets on one (standardized) card [also see Weick, 1982, p. 674].

Implications of Loose Coupling for PD

If adopted the implications are vast not only for school administration but for PD also: According to this theory, loosely coupled systems[21] tend to defy the external requests (i.e. from outside the system) to change (see point one above). Unlike in

[21] This statement does not refer to the individuals but to the system as such.

more standardized organizations in loosely coupled systems (e.g. schools) there is a much lower sense of interdependency between the different actors in the school, also there not necessarily has to be a perfect consensus on goals or the means to attain those goals [cf. Weick, 1982, p. 1] for the educational organization to function properly. Every single teacher in her/his classes can be viewed as a system which is only loosely coupled to other systems [22] and in some regards self-determined. This affects teacher cooperation and bears important implications for PD – for it supports the idea that PD that is initiated externally (from outside the system) and does not manage to intrinsically capture the interest of the individual teacher – is likely not to produce a sustainable change of behaviour. The loosely coupled system is an important cause for the self-contained classroom (SCC) that Lortie described above – the lack of shared variables with other systems in the school allows the teacher to autonomously act as a gateway between all external systems and his own classroom without the other systems for lack of insight being able to take notice (or even reprimand) the teacher's classroom system. In case the science teacher training manages to convince the teacher to transfer certain concepts or principles another systemic problem arises. Once the training is over the teacher returns to his/her institution and thus also returns to the loosely coupled system that is his/her classroom. In the self-contained classroom, the teacher systemically is virtually "left alone" with the task of transferring the often theoretical contents of PD into his/her practice under reflection of the school conditions he/she is working in. Inside the SCC however the teacher is less likely to receive motivation or creative input that could guide him/her on the on the path to an individually sound and sustainable implementation of beneficial concepts. Without even wanting to the teacher might fall back into her/his old patterns – as in the loosely coupled system of the classroom there is little external structure providing incentive, direction or supervision to stick to one's own plan.

Weick's pattern description also implies that PD in order to make a system-wide change has to tackle all loosely coupled systems, that it aims to affect individually – each one at a time. In other words, each teacher would have to be addressed – inside his/her classroom at best – as an individual system. As an alternative, the teacher training itself would have to transfer the loosely coupled systems into a (more) coupled state, before administering its PD content.

These implications are unresolved issues in many cases acting as barriers to the successful transfer of knowledge into practice. In section 10.5 we will look at ways and means for science teacher trainings to possibly resolve some of the implications mentioned here.

[22] E.g. the system of a science colleague and her/his classrooms or the administrative system headteacher and teacher.

3.6 Reflections on International teacher trainings from a network perspective

An international teacher training has some singularities, that separate it from other forms of PD and even from regular science teacher courses that take place on a more regional level. International science teacher trainings are especially interesting constructs when regarded from a network perspective.

When being concerned with science teachers networking and exchanging formally as well as informally inside a science teacher training it is very sensible, to look at these networks from a theoretical perspective also. Understanding the features of networks is a crucial step in being able to create synergetic structures between the communication inside the formal structures of a science teacher training and the communication inside the informal structures of a network of teachers. One ground-breaking networking theory was published in 1973 by sociologist Mark S. Granovetter.

In his paper "The Strength of Weak Ties" Granovetter develops a concept for the "diffusion of influence and information, mobility opportunity, and community organization" [Granovetter, 1973, p. 1360]. The theory was able to provide a sophisticated explanation for the phenomenon of the diffusion of information inside macroscopic networks. The following passage aims at giving a brief overview on some of Granovetter's key ideas.

Imagine two people, assume that the strength of a social tie between those two people can be seen as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie." [Granovetter, 1973, p. 1361]. Following this logic, Granovetter begins to differ between three different types of ties:

- strong ties between two people mean that they spent a lot of time or share a deep emotional connection,
- weak ties mean that the time spent is rare or there is no deep emotional connection between these persons and finally
- no tie – which is self-explanatory.

According to Granovetter, one is able to depict even larger social networks roughly by using dyadic structures while sticking to the following hypothesis:

Think of two persons 1 and 2 and a group of friends 3,4,5 with ties to either one or both of them. Granovetter's assumption is that the stronger the connection between person 1 and person 2 the more likely it is that there are connections between 3, 4 and 5 and both person 1 and 2. These commonalities in friendship circles are predicted to be most when the tie between 1–2 is strong, intermediate when it's weak and least when the tie is absent. Granovetter predicts that a strong link between a person A and a person B and a strong link between person A and a person C must mean that person B and C at least share a weak link between each other. A combination like this:

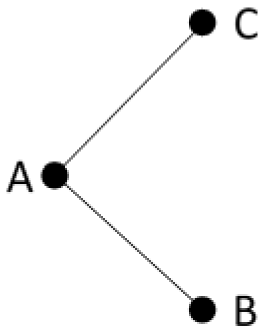


Figure 3.5 "Forbidden Triad" [cf. Granovetter, 1973, p. 1363]

in this Granovetter's network model is never to be found. This idea however has major implications for the diffusion of information inside larger networks. Essentially it means, that whenever there is a connection that is the only path between two people and thus also the only bridge between otherwise entirely separated parts of the network, they are bound to be weak ties, because following Granovetter's model no strong tie can ever be "the last bridge", in that sense, that parts of the network are entirely cut off without it. The diffusion of information in this regard depends on weak ties in order to reach every part of the network or at least to abbreviate the network-jumps necessary for an information to reach a certain point within the network. Look at the following depiction (Fig.3.6):

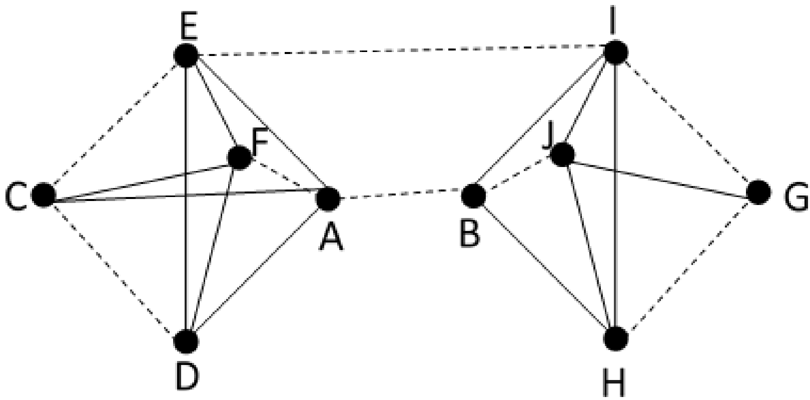


Figure 3.6 “Two networks bridged” comp. [Granovetter, 1973, p. 1365]

The path A-B is not the only path available between those two networks and thus not a “bridge” in the strict sense of the word as defined above – without the connection A-B the information could still travel from A-E-I-B, but A-B it is the shortest connection.
In larger networks the travel-distance for any information can become relevant, with too many network-jumps distances will act as a barrier in itself (see Fig. 3.7).

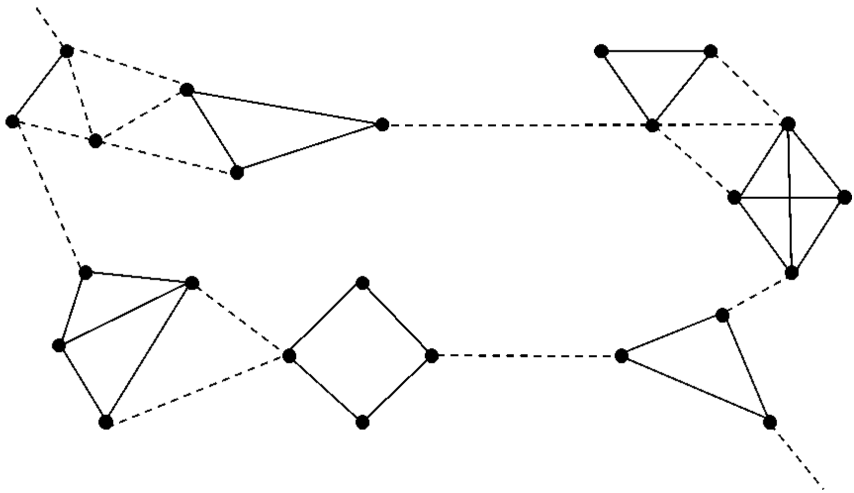


Figure 3.7 “Larger network bridged” comp. [Granovetter, 1973, p. 1365]

Though paths between A and B are available without A and B being connected, it is highly unlikely that the information sent from B will reach A without their weak tie – too distant are the parts of their networks.

For the diffusion of information, according to Granovetter, those people are best suited that share a lot of weak ties because some of them are likely to act as local bridges between networks and thus help to spread the information into a different (or unknown) part of the network.

The formation of networks, according to the rules laid out by Granovetter, have been highly influential on network theory and could explain several previously unexplainable phenomena from Epidemiology and have become a standard in network theory [Stadler, 2013a, p. 58, Burt, 2004, p. 353]. The implications of Granovetter’s models for the distribution of information are very high. According to Granovetter’s theories, parts of the network that are less connected are much more likely to contain unknown and new information than parts of the network that are not in touch are more likely to have developed different ways of solving comparable problems.

3.6.1 Implications of “Weak Ties” for PD

For an international science teacher training course like ours the implications are manifold:

In general, participants from different countries are likely to never have met before. From the social network point of view they belong to entirely different and distant parts of a global network of teachers and as they come together can be regarded as a group of people having no ties towards each other.[23] According to Granovetter, every participant thus is likely to hold highly relevant knowledge for all the other course participants. The course itself may decide to accept the task of acquainting the participants of the course with each other and dedicate some of its time and effort to enhance or facilitate the networking of its participants. By altering the science teacher training's disposition towards each of the participants from mere recipients of a training to potential sources of valuable information for all a science teacher training may be able to actively use its networking position to increase and possibly stabilize the flow of information through the weak ties of its participants. In case a science teacher training course then implements strategies to include teachers' professional strategies and experiences as part and parcel of the science teacher's training concept, it might turn out to create an increase in communication and added value for all participants.
We will later show, that our data contains clues that the CAT course might have been used by the participants in a manner quite like that (for more see chapter 8).

3.7 Reflections on International teacher trainings from the perspective of group dynamics

In analysing social relations inside science teacher training courses by means of sociometry (see pages 140 and 151) and tools of network analysis (see pages 46 and 147) we find ourselves confronted with a hidden set of rules that guides and permeates every group behaviour. This set of rules has first been explored by Kurt Lewin in his Research Centre for Group Dynamics at the Massachusetts Institute of Technology in 1945.

Group dynamics understands itself as the doctrine of the legality of preconscious and unconscious processes in groups, independent of their respective intelligence, and largely independent of social classes[24][Brocher, 2015, p. 45]

Brocher [2015, pp. 28–29] describes the tragic development, that the field took in Germany, when in 1933 Germany lost 70% of all scientist of this field, which according to him lead to many prejudices against the field never being resolved and even expanding to an extent, that in Germany psycho-analytic knowledge is

[23]Exceptions are participants who have known each other before the beginning of the course.
[24]Translation by the author.

considered obsolete. Brocher shows that in other countries like the U.S., Britain, France, the Netherlands, Belgium and Switzerland group dynamics became an important and subtle instrument of group managers. (ibid.)

Tobias Brocher, founder of the journal *“Gruppendynamik”* and from 1962–1970 professor for social psychology at the Johann Wolfgang Goethe University, Frankfurt explicitly looked at the effects of group dynamics on training courses:

In congruence with many constructivist learning theories, Brocher [2015, p. 23] states it to be common knowledge that the learning aptitude inside courses increases, as long as the individual learner is not only a passive recipient of facts. As soon as the learner is given the opportunity to partake in an active manner, this according to Brocher can lead to an increase in knowledge, that may even result in an altered personality. Brocher additionally notes that Kurt Lewin in the 1930s showed that learning aptitude as well as behaviour largely are dependent on the style of leadership and teaching (ibid.).

3.7.1 Different forms of leadership

Kurt Lewin in the 1930s analysed different styles of leader ship of groups. Lewin differentiated three management styles:

- autocratic
- democratic
- laissez-faire

The autocratic style proved to result in quick decisions.

3.7.2 Object relations theory

According to the object relations theory, the way that individuals relate to other persons and situations is instilled by experiences in early childhood. Brocher [2015, p. 46] states that according to the theory early childhood experiences like neglect, abuse or appreciation and love are turned into objects in the unconscious that are then retrieved time and again by the person holding them in order to predict other people’s behaviour. The child identifying with its parents (usually with the parent of the same sex) internalises the rules and vetoes of father and mother. These internalisations turn into an inner conflict between pulsional desires and social imperatives. The probable reactions towards objectionable and forbidden pulsional desires are anticipated and either delayed, supplanted or replaced. Brocher shows that every later stage in life unconsciously is connected to the objects of our first relations – this according to Brocher [2015, p. 26] has direct implications for adult education – as the loss of affiliation to a group (e.g. at the beginning of an international science teacher training) calls into question an individual's identity possibly resulting in a state of *"crisis"*. According to Brocher, we need to be aware that closely connected to the early childhood's object relations a learning process took place that is known to unconsciously persist [Brocher, 2015, pp.25–27]. Regarding training courses, Brocher states:

> *"By no means is there only a business-like transfer of knowledge, including only rational, intellectual learning processes, but at the same time through emotional processes (e.g. affection, aversion, discontent, defiance, boredom and so forth) the learning is advanced or hampered."*[25] [Brocher, 2015, p. 27]

Brocher criticises that these aspects play a far greater role than currently acknowledged by most (ibid.). For adult education the previous experiences regarding object relations and identity according to Brocher have a greater meaning as a large part of the participants are motivated by these unconscious parts of their psyche. Brocher suggests differentiating between the conscious wish to learn and an unconscious wish to alter the object relation of one's childhood. The latter according to him shall neutralize or overcompensate an earlier object relation the former while on the surface aiming for an increase in knowledge at the same time may lend some of its driving force from the unconscious formula *"knowledge is power"* (ibid.).
[Brocher, 2015, p. 27] highlights that the following crucial fields are interpreted by many actors in the field of education as largely being a matter of interest:

- the attention or avoidance toward certain fields of knowledge,
- the consistency of interest,
- the attainable change of attitude and behaviour.

Research in the field of group dynamics however found this to be only partly true as the unconscious and irrational reservations of prejudices are crucial factors operating at the same time [Brocher, 2015, p. 27].

In Brocher's opinion the teacher (or trainer) needs to be aware of the fact that the **subject of the training** challenges the individual to either *extend*, *confirm* or *revise* his or her held beliefs regarding a certain subject. This however cannot be

[25] Translation by the author.

interpreted as an individual's mere repositioning of the subject matter itself – it rather has to be seen as an integration of the subject matter into the individual's philosophy or world-view. Psychologically it equals a confrontation of the familiar self with non-integrated objects and external object relations. This is accomplished by unconsciously triggering and comparing all earlier object relations with the situation at hand. In this way the object of learning (subject matter) unconsciously is likely to contain aspects of object relations providing gratification or demanding renunciation of drives. Every trainer thus needs to be aware that the learner's relation to the object of learning often is then unconsciously projected onto the trainer [Brocher, 2015, p. 28].

> *"[...] viz. the teacher*[26] *is unconsciously associated with related aspects of the object, meaning the primarily unconscious, emotional relation to one or both parents rooted in the childhood. This the instructor in adult education should be aware of in order to correctly deal with the resulting psycho-dynamic processes in the individual.*[27]*"* [Brocher, 2015, p. 28]

Every extension of self – and thus every learning process – according to Brocher is associated with a subliminal identity crisis of related to an individual's self-esteem, that can result in different states of the person. These states are heavily depending on the way that an individual's new identity within the group of learners is related to that reference group. Brocher states that resistance, dynamic and agreement inside of a group (training course) are determined by the level of identity crises that each individual goes through:

> *"Learning processes of the individuum and the group as a whole are in a specific, emotionally justifiable relation with each other [. . .]. A consensus of group members is only possible by means of an at least temporary identification or partial identification. The term "dynamic" means, that in every group there are processes, that are based on the relations between members, between them and other imagined or real groups or persons and between them and the group leaders. [...] Normally the adult does not identify with the complete demeanour of another person (with the exception of falling in love temporary), yet only with specific parts, for example manner of speaking, formulation, feeling tone, movement etc.*[28]*"* [Brocher, 2015, p. 47]

On the word of Brocher next to speech, preverbal articulations like facial expressions, gesture, unconscious movements are used by every individual to put him-

[26] or trainer
[27] Author's translation.
[28] Author's translation.

or herself into a certain structure. Brocher also states that these structures can be made visible by the use of *"sociograms"*. The informal communication before or after the work sessions play a considerable role in creating this structure. The exchange of information among participants as well as the in- or exclusion of participants, as well as gossip and the exchange of opinion about the trainer serve specific purposes and the growth of the group member's sense of belonging [cf. Brocher, 2015, pp. 48–49].

According to the group dynamic theory, every individual attending a training course constructs an **emotionally** founded relation towards the other participants, towards the setting that the training takes place in, to the trainers, towards the content of conversations overheard etc. that is based on previous experiences and prejudices of his former psychosocial reality:

"[...] in the process his perception like through a filter can be altered by his respective mood, by unconscious assumptions and by emotions; it may in this way deviate from reality in a tendentious manner and accordingly isolate or paint reality in a certain direction" [Brocher, 2015, p. 49].

In an example Brocher describes the listener of a lecture, being influenced by a several of above mentioned unconscious factors. This example in a very telling manner gives an account for the mechanisms that in a very similar fashion are happening inside science teacher trainings:

"The listener identifies with the contents of what is being said, as with other listeners or discussion participants, and their behavior, while at the same time rejecting other parts or participants who are to be largely excluded from the consciousness, because the listener cannot identify with them, without abandoning his own previous identity, viz. giving up too many habitual attitudes of his state of consciousness, his search tendency strives for a confirmation of the self-emergent contents and associations appearing in himself. At the same time he examines the offered content, in how far he can agree or disagree with it in relation to his previous state of consciousness. In case the offered content happens to present the reverse, viz. if the previously affirmed tendencies are denied and his negative ones affirmed, he then becomes involved in an ambivalence conflict and attempts to overcome the resulting disturbance or anxiety. The listener consequently is in doubt about the correctness of his previous ways of thinking and the correctness of his behavior, and perceives this process as extremely unpleasant because it plunges him into uncertainty. His way of reacting will be all the more ambiguous the more the content of the presentation meets certain individual preferences

previously experienced as conflictual. Against any mobilization of such conflicts, which in his former world of experience were kept away from consciousness by means of certain defence mechanisms (repression, denial, projection, etc.), he will first react with the same defence mechanisms, and proceed so long until sufficient non- fear inducing support is granted, by means of a relieving methodical procedure, that helps him to gradually familiarize and finally identify with the new content, previously rejected."[29] [Brocher, 2015, p. 50]

In such manner unconscious primary object relations will have a great influence. Consistent with group dynamic research the spectrum of emotional reactions is limited. The basic emotions:

- Fear of rejection, love deprivation
- Diminution of self-affirmation
- Jealousy and rivalry
- Dependence
- Wish of domination
- Fear of submission

remain the same be it as a child or as an adult. According to Brocher, the adult forms are more sophisticated as the adult is more able to control, to hide, to rationalise and seemingly find superficially more reasonable causes. This however – as Brocher points out – does not stop the mobilisation of primary, unconscious, emotional object relations nor does it the effects of unnoticed prejudices. The early-warning and prediction system developed in childhood is conserved [cf. Brocher, 2015, p. 51].

Brocher highlights that even seemingly neutral and rational topics like politics or history – or science for that matter – that seem not in any way related or even close to effects connected to Developmental Psychology are capable of eliciting emotional resonance. The field of group dynamics assumes different mechanisms to be at play:

Brocher [cf. 2015, pp. 51–52] states that to understand any content, we are forced to comprehend the line of thought and to follow the presentation of the content. As a consequence, we need to at least temporarily identify with the presenter or author. In group dynamics it is clear that people have different

[29] Author's translation.

associations related to the person presenting the new ideas and thus are capable to identify with a presenter in various degrees. The identification process is hampered when the presenter is presenting too many “new” ideas, that collides too fiercely with the previous conceptions or beliefs a person held over the subject matter.

This finding has far reaching consequences for any teacher training: It means that in order for the individual participant to willingly accept the content of a training and for the content to unfold a transformative quality in the sense of professional development of the individual, instead of a rejection of the content due to unfavourable constellations regarding a subject’s object relations, the individual’s subconscious reactions regarding the object relations toward the trainers or the content needs to be factored in and needs to be actively reflected, in order to react accordingly.

CHAPTER 4

RESEARCH ON TEACHER QUALITY AND TEACHER PROFESSIONAL DEVELOPMENT

4.1 A brief history of Educational research on PD

Educational research on teacher professional development has not been around for very long. Though the need for professional development of school staff was recognized in the US as early as in the 1960s [Murphy-Latta, 2008, p. 19], the beginning of educational research work in that field that started to have an impact on educational practice and politics can be traced back to the turn of the millennium. Lipowsky states that roughly from 2005 onward teacher quality and with it teacher professional development has come more and more to the attention of educational science [Lipowsky and Rzejak, 2015, p. 26]. In 2007 the growing focus on the teacher quality and its improvement through PD has become official European policy: In their communication from the commission to the council and the European parliament with the title *"Improving the Quality of Teacher Education"* the EU publicly recognizes, that research had shown, that *"teacher quality is significantly and positively correlated with pupil attainment"* and *"...that it is the most important within-school aspect explaining student performance (its effects are much larger than the effects of school organisation, leadership or financial conditions)."*[Commission of the European Communities, 2007, p. 3].

Indeed studies clearly show the effects the teacher quality has on the learning outcomes of pupils [Darling-Hammond et al., 2005; Rivkin et al., 2005, cf.]. It is safe to say that the field of research is still young and "in the shaping". Attempts to give structure to the research field itself and to influence the focus and methods of research in a sensible manner are visible [Borko, 2004, pp. 4–13] and can be interpreted as the attempt of mapping the road of a young yet more and more established field.[1]

4.1.1 The term professional development

The term professional development inside the field of teaching is rather broad in its nature. The grouping of a "large number of quite different activities" [McKenzie et al., 2005, p. 122] has had negative effects on the scientific discourse – as the discussion *"often lacks clarity"* (ibid.). PD can serve different purposes. McKenzie et al. differentiate the following types of PD:

- Activities intended to facilitate the implementation of policy or educational reforms, which are often taken by large groups of teachers together, e.g. through conferences designed to provide new information.
- Task-oriented professional development aimed towards preparation of staff for new functions, which are often taken by individual or small groups of teachers, and which may include courses, self-study and so on.
- School-based professional development aimed at responding to school needs and serving the aim of school development, and which often involve groups of teachers from the same school working jointly on a problem or developing a programme.
- Personal professional development chosen by the individual participant for professional enrichment and further education. Such activities are often taken outside the teacher's school, either on an individual basis or with teachers from other schools.

[McKenzie et al., 2005, p. 122]

The lack of clarity of the term "professional development" in the field of teaching also stems from a yet to be found, clearer understanding of how exactly teachers professionalize and also what activities actually are to be counted as PD activities. Especially at the frontier between informal and formal PD activities there seems to be some confusion with regards to professional development in the field of teaching.

[1] It is important to point out, that research results in this field are not free of cultural bearings – this work tries to consider this by mainly drawing on educational research reflecting on western civilization.

The lack of an established and well-founded canon of PD activities may also explain how one of the biggest OECD surveys on the teaching profession itself lacks a certain continuity in their understanding of PD:

While the Teacher and Learning International Survey (TALIS) 2007–2008 asked teachers about participation in the following PD activities (within the last 18 months):

- courses/workshops (e.g. on subject matter or methods and/or other education related topics);
- education conferences or seminars (at which teachers and/or researchers present their research results and discuss education problems);
- qualification programme (e.g. a degree programme);
- observation visits to other schools;
- participation in a network of teachers formed specifically for the professional development of teachers;
- individual or collaborative research on a topic of professional interest; and
- mentoring and/or peer observation and coaching, as part of a formal school arrangement.
- reading professional literature (e.g. journals, evidence-based papers, thesis papers); and
- engaging in informal dialogue with peers on how to improve teaching.

[cf. OECD, 2009, p. 50]

The Teacher and Learning International Survey (TALIS) 2013 asked teachers about participation in almost the same activities,[2] however it took the two informal PD activities

- *"Reading professional literature"* and
- *"engaging in informal dialogues with peers"*

off the list and replaced them with:

- *"Observation visits to business premises, public organisations, or non-governmental organisations."*

[2]Though only referring to activities undertaken within the last twelve months

- *"In-service training courses in business premises, public organisations or non-governmental organisations."*[3]

[OECD, 2014c, p. 87]

For the OECD TALIS 2013 study not to look at all the informal forms of PD it surveyed in 2007/2008 and which proved quite popular among the participating teachers can be interpreted in different ways. It could be either interpreted as a slight disregard of forms of informal learning in general, or it could be understood as more of a policy-related problem: The data regarding informal learning might be relevant to educational research, yet from the point of view of policymakers it might be regarded as less relevant: Policymakers might hold the opinion that informal PD as such might abdicate from any direct influence that a formal PD might grant to policymakers. Additionally, they might find informal forms of PD are somewhat harder to grasp and a lot harder to quantify – so the data as such from a policymaker's perspective might be regarded as less meaningful.

Although the reasons for the omission of more informal forms of PD in TALIS 2013 are uncertain, the omission itself is a strong indicator that the significance of informal PD as of now remains somewhat unclear. The strongly frequented item *"engaging in informal dialogues with peers"* inside the 2007/2008 round of TALIS very well could have acted as an inspiration for further investigation into the informal realms of PD taking place within schools. The reluctance to do so might also be interpreted as an insufficient or lacking understanding of the ways teachers really do professionalize and as a lack of initiatives or concepts, that could make use of these datasets.

4.2 The inevitability of in-service science teacher professional development

4.2.1 The inevitability

Looking at John Hattie's influential meta study [Hattie, 2009, p. 119] and its relatively small effect size (d=0,62) inside his study one could draw the conclusion that the effect sizes of teacher professional development activities were too minor (see page 4) to focus on continual professional development (CPD) as the positive motor of change for school performance in science. However, this notion upon closer examination proves to be an error of reasoning as Hattie's study does not

[3] The addition of the item "In-service training courses" on a list that already contains the item "courses/workshops" could also be regarded as a lack of demarcation and differentiation of the concepts of PD.

adequately reflect the inevitability of in-service teacher professional development. In an OECD paper giving strategy advice to educational stakeholders from 2005, the authors note:

"Teacher policy concerns have intensified in recent years due to the profound economic and social changes underway and the imperatives for schools to provide the foundations for lifelong learning." [McKenzie et al., 2005, p. 27]

Todays' pupils are bound to face an increasing speed of developments and effects closely connected to globalization. They see permanent changes in areas like changing job markets, new modes of working, increasing diversity of vocational fields and an abundance of global political, technological or scientific developments [OECD, 2014c, p. 3]. Additionally, within their lifetime they are faced with solving more and more global issues like climate warming, ecological devastation, excess of population, securing the world's food supply and energy crises. Teachers preparing students to face realities and to accept challenges can comply with society's mandate only by picking up key developments in society, whether they are technological, economic, scientific or otherwise. It is important to grasp that this task is not a voluntary amendment to the teacher's job description – but that it marks one of its core elements[4] [heise online, 2014; Merkel, 2014]. Coolahan summarizes the challenges for the teaching profession in the following way:

"An education system needs to serve the needs of society and when that society is undergoing profound and accelerating change, then particular pressures emerge to improve the alignment between the education system and these changing societal needs [. . .] But the teaching profession must be trained and equipped so that it will have the capacity to cope with the many changes and challenges which lie ahead. If it is to retain the confidence of society, the teaching profession must adapt a great deal so that it can act in a constructive manner within a fast changing society." [Coolahan, 2002, p. 10]

This challenge has to be understood in its permanency: The constant and accelerating change within society and the growth of knowledge results in practice and knowledge being less and less canonical but rather turning into a permanent flow of information that teachers can either actively "tap" or miss. This ultimately

[4]The chancellor of Germany, Angela Merkel in her video podcast called upon schools to accept the "digital world" as the greatest challenge and explicitly addressed the topic of qualification of teachers during work as being "very important". See: https://www.bundeskanzlerin.de/Webs/BKin/DE/Mediathek/Einstieg/mediathek_einstieg_podcasts_node.html?id=1265574

results in the great educational paradigm change from “finishing one’s training” to “lifelong learning” from the traditional “learning a trade” to the modern “acquiring competences”. Teachers cannot circumvent the need to adapt to these changes and like their students need to become lifelong learners themselves [see OECD, 2014c, p. 3; Richter et al., 2011, p. 116]. Only by paying close attention to the developments in society, teachers can discuss, select and impart relevant knowledge and competencies to their pupils.

4.2.2 The increasing complexity

Rapid changes in society demand more of teachers and especially of science teachers than meets the eye at first glance. For one there is the demand of the science teachers’ own workplace but there is also the vastness, the increasing complexity and the diversity of their own scientific field – be it biology, chemistry or physics as well as many directly connected fields [cf. Heise, 2009, p. 10; OECD, 2014c, p. 86]. From the science teachers’ average workload as seen in table 3.5 we can deduce that apart from a general core knowledge of their scientific field (e.g. chemistry, biology, physics) their time realistically only allows for a very limited number of other relevant content, that they themselves as individuals can specialize in and that they are willing and able to remain lifelong learners in.

Additionally, to the expertise inside their own scientific field the science teacher needs to put a considerable amount of attention to the field of educational research providing him- or herself with new didactic theories, scientific results for effective teaching or classroom management techniques.

Adding the time and effort, that teachers need to effectively transfer the knowledge into practice and integrate it into their teaching style, to the time needed only for imparting the specific content – we are more likely to get an idea of the complexity of the task, that teachers face in their continual professional development (CPD).

4.2.3 The relevance of inevitability and growing complexity of in-service PD for the design of teacher trainings

The sociological reasoning in section 3.5 shows that new concepts for effective CPD need to make an effort to connect to the science teachers and thus to bring the “gatekeeper” of every classroom onto their side. Sociological patterns active in (science) teachers (e.g. SCC and APP) are likely to require carefully balanced training environments and psychological versed trainers, that grant autonomy and help each teacher in the process of transferring the knowledge into their practice.

In (dis-)covering more and more of society's needs, the school as an institution needs strong and standing bidirectional connections to (several) external partners in educational science, science and civil society. These partners from the fields of science and educational science can help the school to recognize societal needs and developments early on. As stated above the increasing demands towards teachers make it very hard for schools to stay on top of all relevant developments without external input and partnership.

The discussed inevitability of CPD and the increasing complexity inside the profession as well as the need to advance the opening school towards society require a lot of resources. One resource in particular seems of the essence: Teachers require time in order to engage in CPD, to reflect their actions and also time for connecting to external partners. Every design of science teacher training is automatically heavily influenced by the amount of time that an educational system grants their science teachers to engage in CPD. We will look at the teachers' assessment of their available resources with regards to time in the following section.

4.3 Known impediments and facilitations to PD participation

For promising PD concepts in teaching, it is vital to take into account factors that bear a direct influence on the reception of PD. So, what does current research have to say with regards to PD participation, what are impediments and what are facilitating factors?

4.3.1 Impediments

In chapter 3 we took a close look at the representative self-report of a teachers' calendar week and saw an estimate of the time dedicated to certain tasks. Science teachers reported to have an estimated workload of 48,8 hours per week (see table 3.5).

20,16 hours per week were reported to be spent with teaching. School as an institution is in need of teachers to accomplish the task of teaching all students attending. When asked about their resources 35,5% of the schools report to suffer from a shortage of qualified and/or well performing teachers to a certain extend or even a lot. Only 23,5% of the schools report not at all to suffer from any shortage [OECD, 2014a, p. 97].

The reported shortage of teaching staff tends to put schools into an intricate position. Schools that want or need their staff to acquire training at the same time face the problem that every teacher taking extensive training is staff missed in the area of teaching. Thus, schools are often able to “release” their teachers to PD activities for short periods of time only: Asked about the strongest impediments hindering teachers to participate in PD – TALIS 2013 revealed that 50,4% of surveyed science teachers agreed, that the major obstacle was the fact that the professional development conflicted with their work schedule. Time for such a training was also reported as being scarce with regard to family responsibilities. Other hindrances mentioned by surveyed teachers was the lack of incentives to participate in PD activities (48,7%). And also, the costs associated with participation in PD (42,3%). The following table (see table 4.1 on page 65) lists all of the results of the TALIS 2013 survey on question TT2G27 that read: “How strongly do you agree or disagree that the following present barriers to your participation in professional development?”

Table 4.1 Barriers to participation in professional development. Source: OECD, TALIS 2013 Database, Tables 4.14 and 4.14.Web. Complemented by own database extractions and calculations from item [TT2G27].

		Strongly disagree [%]	Disagree [%]	Agree [%]	Strongly agree [%]	Agree & strongly agree [%]
Professional development conflicts with my work schedule	teacher	16	34	38	13	51
	science-teacher	15,4	34,1	37,6	12,8	**50,4**
There are no incentives for participating in such activities	teacher	16	36	33	15	48
	science-teacher	14,8	36,4	33,3	15,4	**48,7**
Professional development is too expensive/unaffordable	teacher	21	36	33	10	43
	science-teacher	21,1	36,5	32,6	9,7	**42,3**
There is no relevant professional development offered	teacher	18	43	31	8	39
	science-teacher	17,5	44	30	8,4	**38,4**
Lack of time due to family responsibilities	teacher	24	40	28	8	36
	science-teacher	23,7	41,8	27,2	7,4	**34,6**
There is a lack of employer support	teacher	26	42	23	9	32
	science-teacher	24,4	41	24,6	9,9	**34,5**
Do not have the pre-requisites (e.g. qualifications, experience, seniority)	teacher	60	28	8	3	11
	science-teacher	60,2	29,1	7,8	2,9	**10,7**

The scarcity of time available by teachers for any form of PD has been noted in scientific literature before [e.g. Heise, 2009, p. 10; OECD, 2014a, p. 86].

Item 2 in the ranking of impediments to PD participation: the lack of incentives for PD participation in teaching did get investigated in a report by the European Commission across several EU countries in 2012:

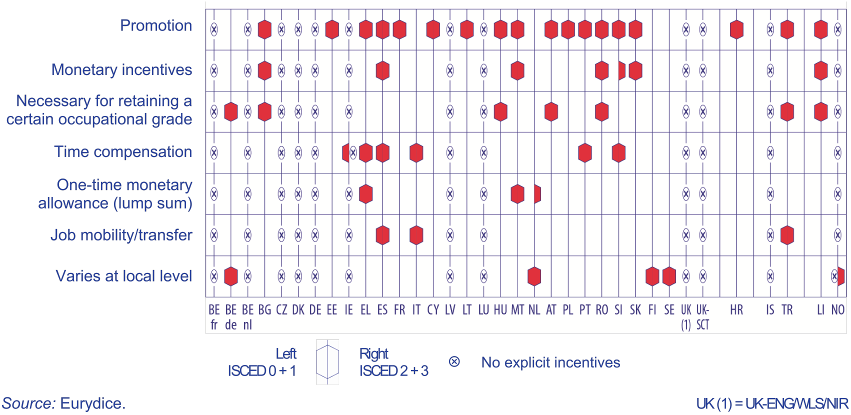


Figure 4.1 Incentives to encourage teachers in pre-primary, primary and general (lower and upper) secondary education (ISCED 0, 1, 2, 3) to participate in CPD, 2011/12. Source: [European Commission/EACEA/Eurydice, 2013, p. 61].

As can be seen from the figure 4.1 *"... the most common incentive to participate in CPD is its importance to a teacher's prospects for promotion"* [European Commission/EACEA/Eurydice, 2013, p. 60]. The data from 2011/12 in many countries shows a scarcely developed or simply inexistent incentive system, generally confirming the teachers' criticism, that apart from increased prospects of promotion external incentives are the exception.

The third largest impediment according to TALIS teachers are the high costs for CPD (listed by 42,3% of TALIS 2013 respondents). Financial support in the eyes of the TALIS 2013 teachers seems to be a highly relevant factor for the participation in teacher training courses. However, the current political situation regarding financial support is somewhat non-transparent: In an EU wide investigation published 2013 the feasibility for financial support was looked into across countries in Europe in 2011/12:

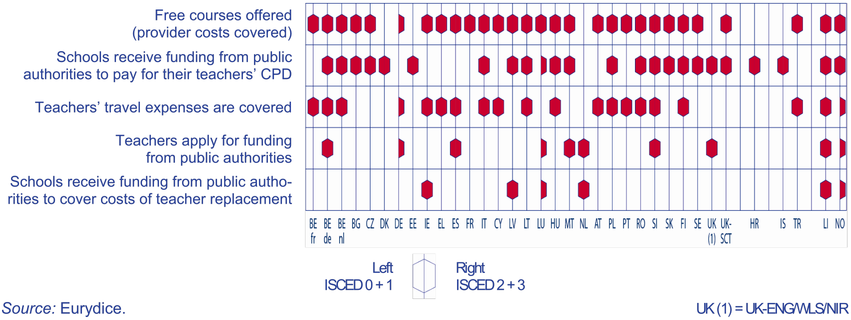


Figure 4.2 Financial support to help teachers access CPD in pre-primary, primary and general (lower and upper) secondary education (ISCED 0, 1, 2, 3), 2001/12. Source: [European Commission/EACEA/Eurydice, 2013, p. 63]

At first glance (see figure 4.2) the situation does not seem to justify the criticism by teachers. Many European countries seem to have free courses on offer during the data collection of the TALIS 2013 round. The CPD *"usually only requires that the CPD is agreed and approved by the school leadership"* [European Commission/EACEA/Eurydice, 2013, p. 62]. The report however also mentions large discrepancies between the countries with regard to the type of formal PD activity that are funded (ibid.) – apparently not all courses on offer are free: So it might be the case, that teachers researching for interesting CPD courses come across courses that indeed were *"too expensive"*.

The somewhat complex relations between financial support and the level of participation had also been addressed in TALIS 2007/08. In the first round of TALIS there had been a negative correlation between the financial support provided and the number of days attended in a training course. The OECD suggested that in countries with less training days per year it was easier to receive financial support, because fewer training days per year meant fewer expenses and thus allowing more teachers to be able to receive financial support. In countries with higher numbers of training days per year the teachers, according to that interpretation of data, either exceeded or depleted the fix budget allocated for PD support and had to finance the costs of the course themselves. [OECD, 2009, p. 66].

With finances and time being listed as fundamental impediments (see rows 1,3 and 5 in table 4.1) from a more political perspective it is quite beneficial to look at data providing clues of external (i.e. political) measures that may help to extend participation in as well as duration of PD activities. It needs to be understood that this data is also highly relevant for the design of science teachers – as the course taken by governments possibly to a high degree shape the circumstances that teachers find themselves under. So a training course developer trying to build a complementary system of PD activities needs to be aware of the (inter-)relations between different ways of support and the length of trainings as well as the participation rates in determining what kinds of teacher trainings are feasible with the current line of educational policy.

As TALIS took place in different OECD nations we can use some of the TALIS 2013 data to determine and display the correlations between support structures and duration as well as participation over multiple nations. It is evident that these correlations not necessarily are in a causal relation and even might be considered arbitrary. Yet if analysed more closely and interpreted correctly they might reveal systemic mechanisms that are worth taking into account.

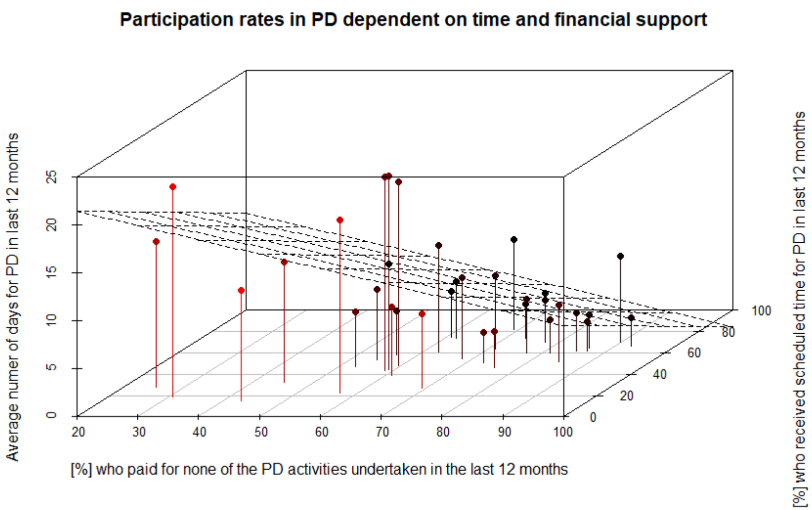


Figure 4.3 Average number of days spend in formal PD activities dependent on scheduled time for PD at school during working hours and percentage of teachers who paid none of the PD activities undertaken. Each data point represents an OECD nation. Source: Own graphic representation of TALIS 2013 Database Extraction.

Our analysis of the TALIS 2013 confirms the data found earlier in TALIS 2007/08: The financial support in 2013 also seems to correlate negatively with the average number of days spent in PD. The average number of days per year also correlated negatively with the percentage of teachers who received scheduled time for PD activities. In the following figure 4.4 we can see a rather strong correlation between scheduled time for PD and participation rates:

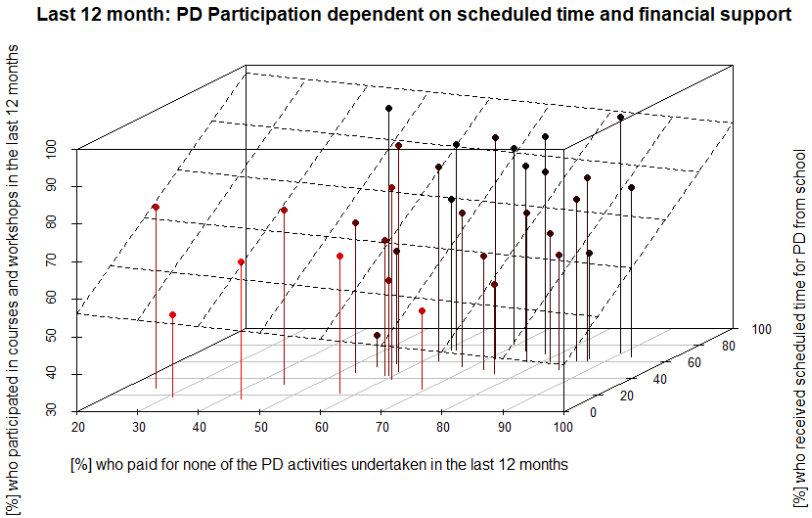


Figure 4.4 Participation rates in formal PD activities dependent on scheduled time for PD at school during working hours and percentage of teachers who paid none of the PD activities undertaken. Each data point represents an OECD nation. Source: Own graphic representation of TALIS 2013 Database Extraction.

As can also be seen in figure 4.4, the participation is possibly slightly negatively correlated with financial support, or at least cannot claim to be a positive factor regarding participation. This neutral to slightly negative correlation is somewhat hard to interpret. Without further analysis it is hard to tell why effects of paid support are not paying off in terms of participation rates. It is also unclear, whether or not financial support is an appropriate measure to stimulate PD participation as there might be many factors inhibiting or annulling possible effects of financial support on PD participation.

On the Z-axis however, we can see that receiving scheduled time for PD activities from the side of the school strongly correlates with participation rates.

From the data available to us however, we may form the hypothesis that under the current system with regards to participation in courses and workshops – time seems to be much more of a critical factor than financial support.

Looking at figures 4.3 and 4.4 we could add another factor to the OECD's reading of their TALIS 2007/08 data: As stated earlier, the OECD saw that a rise in PD participation through financial support correlated with a decrease in the number of days trainings were attended per time interval [see OECD, 2009, p. 66]. The OECD assumed that an increase in participation stimulated through a state paying for teacher's teacher training fees[5] resulted in a stakeholder's reaction possibly enforcing a decrease in the number of days or trainings the stakeholder paid for (thus saving expenses per teacher) in order to grant more teachers access to teacher trainings or PD per se.

The 2013 TALIS data could be interpreted to be adding another important variable into the equation. Analogous and close to the OECD's interpretation and in accordance with the data we would suggest the following interpretation:

1. An **increase in scheduled time for PD** might lead to an
2. **increase in participation** which in return leads to
3. **adjustments in the financial support structure**, that force teachers to
4. **attend fewer or shorter trainings only**, in order to give access to more teachers and in order to prevent the too quick depletion of the financial support pool provided.

This interpretation might point to a possible structural problem, that could only be solved on the level of educational stakeholders and policymakers: As described thoroughly in section 4.2, there is a societal need to grant teachers sufficient access to CPD. Among others, Timperley et al. [2007] and also Yoon et al. [2007] could show a correlation between the duration of teacher training programmes and student achievement (also see section 4.4) which support the hypothesis that the duration of teacher trainings is an important factor with regards to the efficiency of the training in terms of behavioural change on the side of the teacher that then results in student achievement. In case the number of days spent on teacher trainings decreases under a critical level, teacher trainings might become inefficient and without benefit to either the teacher or the student.

[5] Unfortunately, we did not see direct effects of financial support on participation in the TALIS 2013 dataset. We suspect scheduled time to be a stronger factor in that mechanism.

The designer of a science teacher trainings and PD concepts need to be aware of the current educational policies and PD support structures he or she is working under while developing their PD concepts.

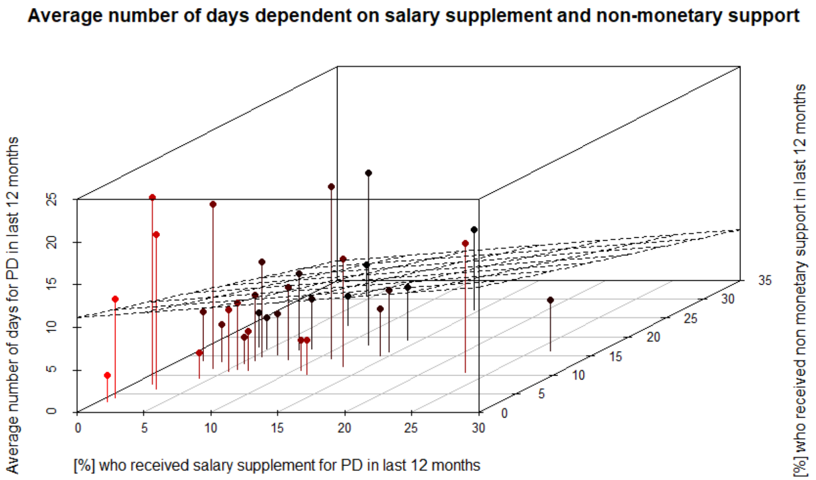


Figure 4.5 Average number of days in PD dependent on salary supplement and non-monetary support. Source: Own graphic representation of TALIS 2013 Database Extraction.

As can be seen in figure 4.5, salary supplement for PD could be a means of increasing the number of days spent on PD while non-monetary support seemed to correlate slightly negatively with the number of days spent on PD. Another analysis showed that neither salary supplement nor non-monetary support seemed to have an effect on participation rates in PD courses or workshops.

As the TALIS data shows, financial support is slightly negatively correlated with participation in workshops and courses over all countries. It seems that effects of financial support need to be investigated further as they do not seem to have a stimulating effect with regards to participation and might even reduce the average number of days spent on PD activities. In case these effects prove to be real they would have to be seen quite critically: On the one hand the duration of PD activities could be shown to correlate with student achievement and on the other hand a reduced duration for trainings due to time constraints might have to rely more on nested verbal reproductions of the subject matter instead of going the somewhat slower route of demonstrating the PD contents in practice and thus increasing the chance for sustainable change in the practice. Those shorter courses are running a higher risk of falling into the inefficiency of a “Nuremberg Funnel” didactics and also in the risk of trying to replace courses and workshops with online courses and workshops that are likely to abstract and abbreviate the PD content even further.

TALIS data from upcoming rounds might show whether educational policy manages to decrease the percentage of science teachers holding on to the criticism of formal PD colliding with their work schedule and being too expensive. Due to our knowledge of the duration of courses and workshops having an impact on whether or not a course is effective it would be beneficial if the average number of days in PD could be increased.

In case the criticism as well as the relatively small number of average days in PD (also see page 82) hold up in future rounds of TALIS, further investigation into the systemic intricacies of the matter will be necessary.

4.3.2 Facilitations and preferences

Both TALIS rounds have given us a glimpse of the preferences that teachers have with regards to the PD activities that they are more or less willing to engage in. The TALIS 2008 and 2013 data show what the teachers reported about their engagement, their average time spent on PD and the perceived effectiveness of different forms of PD. On the next page you can find the data from the 2013 TALIS round (see table 4.2 on page 73).

In terms of impact assessment, it is very useful to directly complement the data from table 4.2 with two informal categories that only were inquired in the 2008 round of TALIS.[6]

[6] It has to be noted that the percentages are not directly to be compared with TALIS 2013 results, as the TALIS 2007/08 results refer to PD activities undertaken in the last 18 months as opposed to results from the TALIS 2013 results referring to PD activities undertaken in the last 12 months.

Table 4.2 Participation rates and average number of days for each type of professional development reported to be undertaken by lower secondary education teachers 12 months prior to the survey. Source: OECD, TALIS 2013 Database, Tables 4.9 and 4.9.Web. Complemented by own database extractions.

	Percentage of teachers/science teachers who participated in the following professional development activities in the 12 months prior to the survey		Average number of days of participation among those teachers/ science teachers who participated	
	teachers	science teachers	teachers	science teachers
Courses/workshops	71 %	**71 %**	8	**10,6**
Education conferences or seminars where teachers and/or researchers present their research results and discuss educational issues	44%	**44%**	4	**4,6**
Observation visits to other schools	19%	**20,6%**	3	**3,8**
In-service training courses in business premises, public organisations or non-governmental organisations	14%	**17%**	7	**10,9**
Observation visits to business premises, public organisations or non-governmental organisations	13%	**15,5%**	3	**3,5**
Participation in a network of teachers formed specifically for the professional development of teachers	37%	**38,9%**		
Individual or collaborative research on a topic of interest to the teacher	31%	**34,4%**		
Mentoring and/or peer observation and coaching, as part of a formal school arrangement	29%	**33,3%**		
Qualification programme (e.g., a degree programme)	18%	**20,3%**		

Table 4.3 Informal PD activities exercised 18 months prior to the survey (TALIS 2008). Source: OECD, TALIS Database. TALIS 07/08 Table 3.2. Complemented by own database extractions.

	Reading professional literature		Informal dialogue to improve teaching	
	%	(SE)	%	(SE)
Teachers	77,7	(0,23)	92,6	(0,14)
Science teachers	79,9	-	92,7	-

The clear dominance of two informal forms of PD inside TALIS 2008, must also be critically reflected under the light of ease of attainment. When asked about PD activities that one engaged in during the last 18 months – partaking in an informal conversation with a colleague or reading professional literature is fuzzier and thus easier to say "yes" to than an active participation in a course or workshop. However, completely dismissing the results regarding those two informal PD activities out of methodological concerns is an inadmissible simplification. As we saw in chapter 3 in table 3.5, teachers in their self-reporting actually do report investing "time for teamwork and dialogue with colleagues" on a weekly basis. Furthermore, the preference for colleagues as a source of information has also been confirmed in other educational research and sociological studies. In TALIS 2007–2008 we can also see, that the "Informal dialogue to improve teaching" is rated by science teachers as being more effective than other formal PD activities (with the exception of "Qualification programmes") (see table 4.4 & table 4.5).

Table 4.4 Percentage of teachers of lower secondary education reporting that the professional development undertaken in the previous 18 months had a moderate or high impact upon their development a teacher. Source: OECD, TALIS Database. TALIS 07/08 Table 3.8. Complemented by own database extractions for science teachers

	Courses and workshops (impact)		Education conferences and seminars (impact)		Qualification programmes (impact)		Observation visits to other schools (impact)		Professional development network (impact)	
	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)
teachers	80,6	(0,23)	73,9	(0,31)	87,2	(0,35)	74,9	(0,50)	80,2	(0,31)
Science teachers	80,8	-	74,8	-	87,3	-	74,4	-	79,5	-

Table 4.5 Continuation of table above

	Individual and collaborative research (impact)		Mentoring and peer observation (impact)		Reading professional literature (impact)		Informal dialogue to improve teaching (impact)	
	%	(SE)	%	(SE)	%	(SE)	%	(SE)
teachers	89,3	(0,30)	77,6	(0,41)	82,8	(0,22)	86,7	(0,18)
Science teachers	88,3	-	76,4	-	84,1	-	85,6	-

So in terms of efficiency the ranking of the most efficient forms of PD according to the TALIS 2007-2008 science teacher cohort would look like this:

Table 4.6 Ranking of moderate or high impact PD activities undertaken in the last 18 months. (Participation data if possible taken from TALIS 2013 with participation percentages only within the last 12 months)

PD activity	Rated as having moderate or high impact	Participation last 12 (or *18) months
Individual and collaborative research (impact)	88,3 %	34,4 %
Qualification programmes (impact)	87,3 %	20,3 %
Informal dialogue to improve teaching (impact)	85,6 %	92,7 %*
Reading professional literature (impact)	84,1 %	77,7 %*
Courses and workshops (impact)	80,8 %	71 %

This data is highly valuable in terms of creating new CPD concepts. The data gives more traditional forms of formal CPD, that are accepted by many teachers, means of sensibly incorporating beneficial aspects from other forms of PD that if introduced in a sensible manner may increase the efficiency of the CPD activity. The idea to investigate informal conversations taking place inside formal science teacher trainings may be a first step to look for sensible ways to merge the benefits of the informal PD activity “Informal dialogue to improve teaching” and the formal PD activity “Courses and workshops”. Looking at the table other promising merges might possibly be found in trying to foster “Individual and collaborative research” from inside “Courses and workshops”. Or maybe even offering “professional literature” on how to start “individual and collaborative research”.

Research has been conducted as to which PD content was rated by teachers to having had a moderate or large effect. It is important to distinguish this rating by the teachers from the actual effects on the student’s achievements. Still, looking at science teachers’ preferences regarding content that is perceived as having a greater effect is helping to understand some of the teachers’ priorities that are likely to be shaping their workplace realities. TALIS 2013 surveyed the impact of trainings regarding their content (see table 4.7 on page 77).

Table 4.7 shows that science teachers tend to rate certain types of content considerably differently than the average mean of teachers. This provides additional evidence to the hypothesis introduced by Kaub (see chapter 3.1.1 on page 18) regarding the group of science teachers representing a different subset with different needs. Educational research and policymakers could use these data in order to detect areas that teachers want to engage in or that they feel especially unprepared for.

Table 4.7 Large and moderate to large effects of PD according to content type. Rated by TALIS teachers. Source: OECD, TALIS 2013 Database, Tables 4.10 and 4.10.Web

Rated effect:	Large [%]		Moderate/ Large [%]	
PD content type	teacher	science teacher	teacher	science teacher
Knowledge and understanding of subject field(s)	24,62	**33,73**	66,03	**90,32**
Pedagogical competencies in teaching subject field(s)	20,22	**30,05**	59,19	**87**
Knowledge of the curriculum	17,32	**33,11**	47,45	**84,78**
Student evaluation and assessment practices	16,81	**30,6**	47,45	**83,73**
Student behaviour and classroom management	12,2	**29,23**	35,35	**82,22**
Student career guidance and counselling	6,69	**29,77**	18,85	**82,17**
Teaching cross-curricular skills (e.g. problem solving, learning-to-learn)	9,27	**26,23**	30,97	**81,9**
Approaches to developing cross-occupational competencies for future work or future studies	5,25	**27,48**	16,36	**81,8**
ICT skills for teaching	16,65	**32,66**	42,91	**81,46**
New technologies in the work-place	11,26	**29,04**	31,49	**80,52**
Approaches to individual learning	10,1	**26,66**	32,71	**80,5**
School management and ad-ministration	5,25	**29,07**	14,05	**78,12**
Teaching students with special needs	8,67	**28,14**	24,51	**77,31**
Teaching in a multicultural or multilingual setting	4,5	**25,65**	12,59	**74,41**

4.4 Current findings on teacher trainings and circumstances

Finding ways for effective professional development has become a high priority for educators, researchers and policy makers. The main idea is, that PD *"could facilitate improvement of teaching practices, which could in turn translate into levels of student achievement"* [Antoniou and Kyriakides, 2013, p. 1; also see Borko et al., 2010; Desimone, 2009].

And indeed studies that found evidence of teacher's professional development having an impact on students' learning are plentiful [Angrist and Lavy, 2001; Borko, 2004; Darling-Hammond et al., 2005; Rivkin et al., 2005]. Additionally, empirical evidence was found for a link between formal PD in the form of teacher training programmes and improvements in students' achievements and teaching skills [Garet et al., 2001; Glazerman et al., 2009, 2006; Penuel et al., 2007]. As stated earlier Yoon et al. and Timperley et al. could show a positive correlation between the total number of hours of teacher training programmes and student's achievement [Timperley et al., 2007; Yoon et al., 2007]. Yoon et al. discovered that an extensive number of hours over a period of 6–12 months shows positive and significant effects on student achievement [Yoon et al., 2007].

The research by Yoon et al. also quantified a lower limit with regards to the duration. As Yoon et al. state only: *"Studies that had greater than 14 hours of professional development showed a positive and significant effect on student achievement from professional development"* [Yoon et al., 2007, p. 12]

The study by Timperley found: *"that under most circumstances, an extended timeframe is needed for substantive learning to occur"* [Timperley et al., 2007, p. xxviii].

Timperley also found that: *"In reading, writing, and science, frequency of contact was particularly important. In most studies that reported on frequency, contact occurred at least every two weeks. In some, contact was less frequent than this, but rarely less than once per month. [...] Extended timeframes and frequent contact were probably necessary because, in most core studies, the process of changing teaching practice involved substantive new learning that, at times, challenged existing beliefs, values, and/or the understandings that underpinned that practice. The learning process was iterative rather than linear as new ideas were revisited in terms of their implications for the ideas on which current practice was based. Providers who trained teachers to implement a defined set of preferred practices rarely had a sustained impact on student outcomes."* [Timperley et al., 2007, p. xxviii]

Despite encouraging findings, the field of teacher trainings has been somewhat neglected in terms of professionalization: The field as such is marked by structural incongruity and a large diversity. Simona Sava with regard to the lack of any professional needs analysis in the field of adult education sums up the situation in the following manner:

"Unfortunately, in a lot of adult education institutions, needs analysis is done in a non-professional manner, based more on the experience, feeling, and information of the programme planner. Conducting a needs analysis is often considered a costly, time-consuming, and unreliable activity; thus the 'trial and error' principle is still the most common approach when it comes to designing adult education programmes." [Sava, 2012, p. 9]

A voluntary OECD analysis of Country Background Reports across 25 countries[7] showed that most current concepts and initiatives of professional development were *"... often fragmented, unrelated to teaching practice, and lacking in intensity and follow-up"* [McKenzie et al., 2005, p. 122].

On the side of educational policy, the majority of European countries today has realized the structural importance of continuing professional development (CPD) as well as the potential of teacher CPD for considerable improvement in student achievement. As a result, the majority of countries has come to declare CPD a professional duty and thus making it mandatory (see figure 4.6):

[7] Australia; Austria; Belgium (Flemish Community); Belgium (French Community); Canada (Quebec); Chile; Denmark; Finland; France; Germany; Greece; Hungary; Ireland; Israel; Italy; Japan; Korea; Mexico; the Netherlands; Norway; the Slovak Republic; Spain; Sweden; Switzerland; the United Kingdom and the United States.

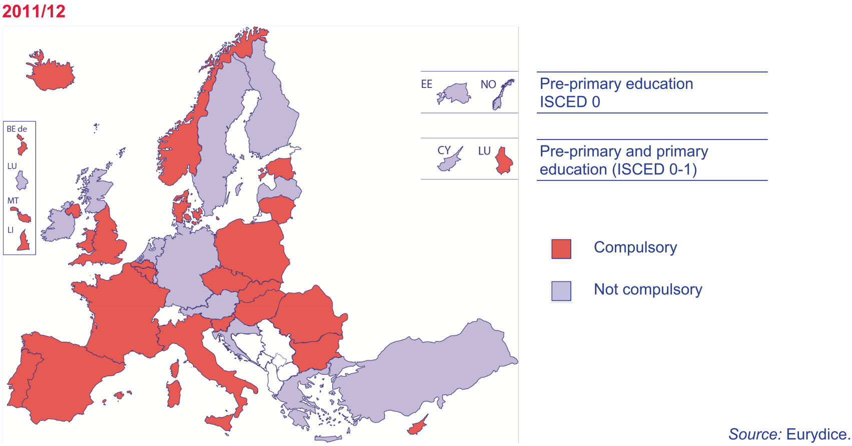


Figure 4.6 Status of continuing professional development for teachers in pre-primary, primary and general secondary education (ISCED0, 1, 2, 3) 2011/12. Source: [European Commission/EACEA/Eurydice, 2013, p. 58]

However, it remains somewhat unclear exactly what and how teachers benefit from different professional development activities or how they professionalize at all [see Desimone et al., 2002; Fishman et al., 2003]. Naturally this lack of knowledge is also valid for research regarding science teacher trainings. A main reason for the difficulty of scientific evaluation of teacher trainings as a heavily frequented aspect of teacher CPD in general is – as Anne Sliwka sufficiently points out in [McKenzie et al., 2005, p. 100] – that the spectrum of teacher trainings is rather broad regarding content as well as methods. As Bodensohn and Jäger [2007] point out: The situation of supply and maintenance with regard to teacher trainings also is somewhat unclear and non-transparent as it is a field that is scarcely documented and/or evaluated:

In most cases teacher training courses or modules seem to be offered by universities and teacher training institutes. There is however some slight cultural variation: In some countries PD is delivered mainly by state agencies – in other countries the state deregulated the market and supplied schools with appropriate funding to organize training adapted to their specific requirements [cf. McKenzie et al., 2005, p. 123].

Though a mandatory professional duty in many European countries (see figure 4.6), in many countries there is no minimum requirement set to participate in in-service teacher training or the general obligation of participation in trainings is (though present) not enacted. In countries that have a minimum requirement (e.g. Australia, Austria, the French Community of Belgium, Finland, Hungary, the Netherlands, Scotland, Sweden, Switzerland and some districts in the United States) the requirement commonly is five days per year with a range from 15 hours per year (Austria) up to 104 hours in Sweden and 169 hours in the Netherlands [McKenzie et al., 2005, p. 123]. The relatively sketchy and sometimes contradicting informational situation regarding the use of mandatory in-service trainings has been made somewhat more transparent through the representative data gathered by the TALIS. Within the TALIS 2013 survey question 21 addresses the participation in professional development activities, and their duration – it states: *"I. During the last 12 months, did you participate in any of the following professional development activities, and if yes, for how many days did they last?"*

Two items refer to teacher trainings: Option a) is referring to:

- Courses/workshops (e.g. on subject matter or methods and/or other education-related topics)

And option e) refers to:

- In-service training courses in business premises, public organisations, non-governmental organisations

The data regarding the use of in-service teacher trainings in business premises, public organisations and NGOs reveal, that in average they had been used by 15% of all TALIS 2013 lower secondary science teachers – the total in-service training time on average was 7,5 days. The international survey also gives a comprehensive overview of how many surveyed (science) teachers participated in courses/workshops within the last 12 months and how many days on average they visited these courses/workshops per year (see table 4.8). The table also serves the purpose of informing course designers and/or maintainers planning international science teacher trainings with regards to viable candidates for promoting international science teacher trainings as well as giving a basis for reflection on the duration of the science teacher trainings designed.

Table 4.8 Attendance of courses & workshops in the last year. Source: OECD, TALIS 2013 Database, Table 4.10.Web and own extraction from TALIS 2013 database.

		Courses/workshops			
		Percentage of teachers attending (2012)	Average number of days in 2012	Percentage of science teachers attending (2012)	Average number of days in 2012 (science teachers)
Singapore	SGP	93	9	**92,62**	**7,94**
Malaysia	MYS	91	6	**90,8**	**6,26**
Mexico	MEX	90	19	**89,99**	**20,05**
Latvia	LVA	89	8	**87,34**	**7,88**
Australia	AUS	86	4	**85,61**	**3,81**
Alberta (Canada)	CAB	85	6	**85,25**	**5,87**
Estonia	EST	82	9	**80,33**	**9,51**
Abu Dhabi	AAD	82	11	**85,19**	**13,05**
Poland	POL	81	7	**77,31**	**5,87**
Croatia	HRV	79	4	**81,11**	**4,15**
Flanders (Belgium)	BFL	79	3	**80,08**	**3,13**
Netherlands	NLD	78	4	**79,93**	**5,07**
Korea	KOR	78	15	**79,02**	**16,19**
Israel	ISR	76	13	**78,45**	**12,82**
England (UK)	ENG	75	3	**75,92**	**3,19**
Denmark	DNK	73	4	**74,63**	**3,76**
Iceland	ISL	70	5	-	-
Serbia	SRB	70	6	**74,55**	**6,18**
Czech Republic	CZE	70	6	**72,94**	**17,03**
Spain	ESP	67	18	**68,72**	**17,05**
Portugal	PRT	67	12	**66,08**	**9,33**
Brazil	BRA	66	20	**61,2**	**21,3**
Norway	NOR	64	3	**61,36**	**3,36**
Bulgaria	BGR	60	6	**64,47**	**5,46**
Finland	FIN	60	3	**62,77**	**2,88**
Japan	JPN	60	5	**59,74**	**4,64**
Sweden	SWE	58	4	**64,78**	**3,67**
Chile	CHL	55	20	**53,03**	**19,97**
France	FRA	54	4	**56,47**	**3,54**
Romania	ROU	52	22	**59,1**	**21,44**
Italy	ITA	51	8	**57,98**	**7,55**
Slovak Republic	SVK	39	7	**41,1**	**7,99**
United States	USA	-	-	**86,16**	**10,02**
Overall Average		71	9	**73**	**10**

4.4.1 Teacher training courses and time

The time available for PD activities has already been addressed in the chapter on impediments to PD (see table 4.1 in subsection 4.3.1). The reported scarceness of time (or opportunity) obviously is valid for science teacher training courses as well as for other PD activities. According to Maren Heise's estimate, the situation will intensify as increasing fields of responsibility for teachers are taking up more and more resources and according to Heise require "new ways of learning that can be implemented more informally on the job" [Heise, 2009, p. 11]. Heise's suggestion is reasonable – opposed to some of the more informal forms of PD, teacher trainings in general require a more or less large amount of time at a stretch.

While some of the trainings are organized in more local settings (i.e. taking place in a school, or some form of local conference centre) that allow teachers to return to their homes after a training session other science teacher trainings chose more remote, often attractive locations that allow for more withdrawal from everyday responsibilities and possibly more dedicated time inside of the teacher training. Though as of yet no research work seems to be available investigating the interplay of time and location empirically, it is probable that the location and circumstances have a direct influence on the work modes available to trainers (also from a group dynamic perspective) as well as an influence on the individual's attitude and the focus and concentration of all teachers attending.

In subsection 3.1.2 we already mentioned the sociological results indicating, that the teaching profession had several attractors to it – among them the so called *"Theme of Time Compatibility"*. Through analysis of the interviews lead in five towns in the Boston area, Lortie comes to the conclusion, that through the specialty of teacher's holidays mostly aligning with the student's holidays – the teaching profession's *"Time Compatibility"* is explicitly mentioned by many interviewees as a highlight they believe to be of great importance to many of their colleagues [Lortie, 2002, pp. 31-32]. It is likely that the *"Theme of Time Compatibility"* might be a typical vocational personality trait that in some cases might affect their ability and or willingness to take dedicated time off, in order to participate in teacher trainings. It is possible that the degree of flexibility also correlates with certain aspects of the personal life and thus often with age. Although Richter's research (see figure 3.3A) indicates that the general attendance of In-service training peaks around the age of 42, we have no information whether trainings that require larger stretches of time are primarily attended by teachers, who are either younger (and without a family of their own) or older (and in a state where children either already left the home or can stay at home unattended) and whether for example more local trainings allowing for a quick return home are the preferred choice of teacher training of teachers being part of families with younger children. Research in this field also with regard to Huberman's career stage model might prove rather valuable in terms of teacher training design.

The total amount of time that teachers are granted, obliged and willing to dedicate to PD – as well as the (financial) support they are receiving are creating feedback loops on the formal PD system that are influencing the ways that science teacher trainings are operating, the following ideas are examples that demonstrate the complexity of the PD in teaching and demonstrate that consistent solutions always have to reflect and incorporate the political sphere:

1. Teachers that are experiencing conflicts with their work schedule in accordance with their school administration might be more likely to decide to attend shorter teacher trainings. In general, teachers experiencing conflicts with their work schedule also might end up in spending less dedicated time for reflection of their own practice.

2. As the TALIS 2008 & 2013 data shows, the amount of financial support correlates negatively with the duration of teacher trainings. This as an OECD report suggests might be due to the pool of financial support being limited thus in order to benefit as many teachers as possible limiting the amount of time that teachers can take teacher training courses [OECD, 2009, p. 66].

3. The organizers of trainings react to the lack of time dedicated to formal PD as well as to the lack of financial support by shortening time of the courses duration (see below)

Two datasets, that the author extracted from public websites can exemplify the situation:
In Germany the duration of all 279 teacher trainings on offer on the Landesbildungsserver BW on 24.09.2014 [Landesakademie für Fortbildung und Personalentwicklung an Schulen, 2013] had a duration of between one and five days. The majority of trainings on offer had a duration of only three days or less, including the travel time towards and from those trainings. The Landesbildungsserver BW in 2014 did not present any limitations regarding the duration of trainings.

Regarding the Comenius/Grundtvig training database, an aggregation service for "In-Service Training for School and Adult educators 2014" [European Commission, 2014] acting on a European level, the duration of the in-service trainings were slightly higher: In the figure below, you can see the distribution of the duration of the teacher training courses from the Landesbildungsserver BW as well as from the Comenius/Grundtvig database (not including travel).

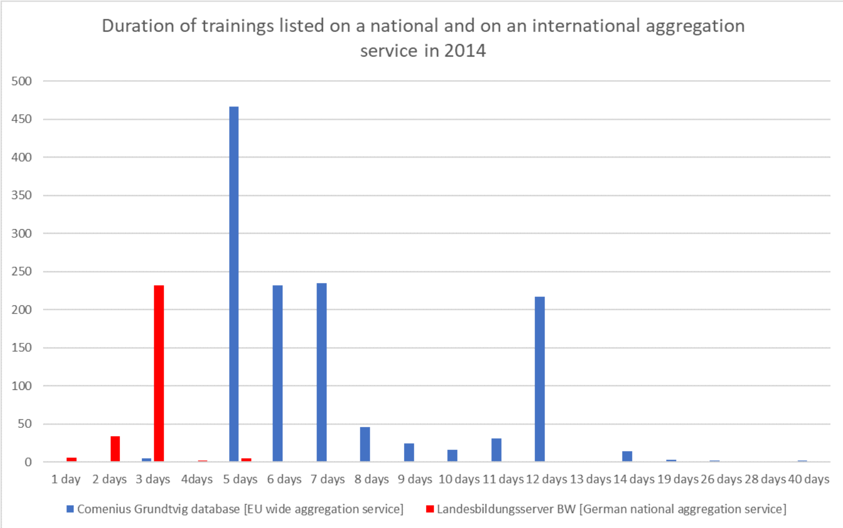


Figure 4.7 Duration of listed teacher trainings in two aggregation databases. Source: Own research.

This difference in distribution of duration of in-service teacher trainings can be explained by taking a look at the "Instructions for Training Providers" which explicitly demand that the duration of a structured course inside the Comenius/Grundtvig database should at least last five working days excluding travel time [Lifelong Learning Programme of the European Commission, 2012, p. 3]. The maximum possible duration for Comenus/Grundtvig courses is listed with six weeks (ibid.).

The database listed 1300 teacher trainings for 2014 just before it closed in June of 2014. More than a third (467) of all trainings by providers listed in the Comenius/Grundtvig database for 2014 did not extend the duration of their training beyond the bare minimum required to be listed inside the database.[8] The data might point to the effects described above – but also shows that a regulation of the effects in principle is possible.

[8] Some of the in-service trainings found their way in the Grundtvig/Comenius database despite being shorter than required in the "instructions for training providers" – no further inquiries were made.

4.4.2 Levels of impact for teacher trainings

Studies are only beginning to discover empirically successful methods for teacher trainings [Buchholtz, 2010, p. 217]. In their article "Was wir über gelingende Lehrerfortbildung wissen"[9] Lipowsky and Rzejak [2015, pp. 26–27] suggest a differentiation of four general target levels of teacher trainings to measure trainings by:

1. Immediate reactions of the participants aiming at
   (a) relevance of the training content
   (b) the level of satisfaction for participants
   (c) the participants' learning proceeds
2. the transformation of cognitive and affective-motivational characteristics of a teacher
3. changes in the teaching modalities and in the quality of lessons
4. effects on the learning of students[10]

Lipowsky and Rzejak [2015, p. 26] stress that the main focus of teacher trainings should reside on affecting the learning of students (fourth level). However, the other target levels should not be left out of the equation. Though the immediate reactions towards a training constitute a valuable source of feedback, they do not necessarily give information about sustainable learning processes involved. As Lipowsky and Rzejak point out, a training aiming at change or extension of firmly held beliefs or attitudes might be cause for discontent and dissonance right after the training – while positive acknowledgements often only come with experience of competence at the end of a learning process [cf. Lipowsky and Rzejak, 2015, p. 27]. Little is known however, whether positive effects on level one do have an impact on other vital areas of teacher trainings.

Any person involved in the design of a teacher training course is best advised to carefully differentiate between and familiarize with the above-mentioned levels and ought to be aware of ways of establishing the effects and the impact that the course had on each level separately in order to be able to draw conclusions on possible inter-level effects.

The first level can be summarized as the personal feeling or attitude of the participating teachers towards the training. Feedback surveys and interviews can

[9] "What we know about working teacher trainings".

[10] Effects on this level were analysed in Hattie's meta study from 2009 [Hattie, 2009, pp. 119–121].

help to shed light on this level. Often informal conversation with participants and close observation can provide complementary data.

The second level is the transformation of a teachers cognitive and motivational mindset which according to Hattie's meta study more often than not does not include a change in the way teachers actually behave inside lessons [Hattie, 2009, p. 120]. This level can be validated via tests and questionnaires [Lipowsky and Rzejak, 2015, p. 27].

The third and fourth level reflect the actual change in the participants' teaching and the change in student's learning respectively. In most traditional formalized teacher training conceptions, effects on these levels can only be determined after the end of the training. In current educational research however the majority of studies do not measure the impact of teacher trainings on quality of teaching and on student outcomes [Antoniou and Kyriakides, 2013, p. 1]. In order to find out whether the training was successful regarding level three and four the lesson of the teacher training participant needs to be made a subject of closer observation or even research. A suitable and well researched method to collect data regarding level three is the use of a camera: Teachers can film their lesson and then use the material to gather information on her/his own (re-)actions or the (re-)actions of her/his students [also see Welzel and Stadler, 2005]. The interpretation and analysis of said video material can either be a part embedded in a more sophisticated teacher training course or can become part of action research undertaken by the teacher her-/himself [see Altrichter et al., 2008]. Effects of regarding the level of student learning itself is most likely determined by the outcome of tests.

Findings support the focusing on a single subject matter topic (e.g. light and colour) or a specific competence (e.g. scientific reading) and encourage maintainers of teacher trainings to go into depth rather than in width regarding the topics addressed in the course – current research shows that those trainings tend to have effects down to the level of student achievement [Lipowsky, 2014; Lipowsky and Rzejak, 2015].

Timperley points out that there are indications of self-efficacy also acting as prerequisite for professional development of teachers [Timperley et al., 2007]. Lipowsky emphasizes the importance of teacher trainings bringing participants of the trainings in touch with the effects their teaching has had on their pupils in order to foster further development [Lipowsky and Rzejak, 2015, p. 28].[11]

[11] It has to be mentioned, that this requires the teacher trainer to keep in touch with the participants well after the training has ended. A model that probably for financial reasons does not constitute the norm at the moment.

4.4.3 Paradigm Shift of teacher trainings in the U.S. and the call for broader research

Borko et al. state that paradigm shifts in the ideas of the nature of cognition, learning and teaching from behavioural to cognitive to situational in educational research have been escorted by parallel shifts in the ideas about teacher learning and PD: Traditional models, in which teachers have to learn clearly defined bodies of skills through a well-specified process, often inside single workshops or courses taught away from school premises are being replaced by more constructivist and situational theories and reform efforts also based in classroom practice and incorporating the formation of learning communities [Borko et al., 2010, p. 548]. The new model of PD thus acknowledges that today's role of teachers requires PD to move from merely teaching "techniques" toward the use of multiple PD complementary strategies imparting knowledge in the fields of CK, PK and PCK [see Borko et al., 2010; Hargreaves, 2000; Heise, 2009; Stein et al., 1999].

Based on "literature reviews and accounts of successful PD programs" educational research in the U.S. has moved in the direction of generating "lists of principles or features of high-quality PD" [Borko et al., 2010, p. 548]. After reviewing literature Hilda Borko et al. compared six of the most exemplary reports of American PD research by nine renowned experts in order to "capture much of the current thinking" [Borko et al., 2010, p. 549]. In many of these reports there is agreement that the content of a teacher training course should be situated in practice as well as it should address problems of practice (3/6) [e.g. Darling-Hammond and McLaughlin, 2011; Knapp, 2003; Putnam and Borko, 1997, 2000]. The content of the PD should in some form or another be dealing with student learning itself (3/6) [e.g. Darling-Hammond and McLaughlin, 2011; Hawley and Valli, 2000; Knapp, 2003]. Several reports suggest a section within the course that allows the teachers to discuss their preferred instructional practices (3/6) [e.g. Darling-Hammond and McLaughlin, 2011; Knapp, 2003; Putnam and Borko, 1997, 2000]. Also most leading experts in the field advocate active learning and forms of teacher inquiry (4/6) [e.g. Darling-Hammond and McLaughlin, 2011; Hawley and Valli, 2000; Putnam and Borko, 1997, 2000; Wilson and Berne, 1999]. Interestingly enough all of the comprehensive reports chosen by Borko et al. mention the need for teachers actively participating in professional learning communities (PLC) and collaborative learning environments (6/6) [e.g. Darling-Hammond and McLaughlin, 2011; Hawley and Valli, 2000; Knapp, 2003; Putnam and Borko, 1997, 2000; Wilson and Berne, 1999]. Borko et al. summarize this unity among leading U.S. PD researchers the following way:

"... the opportunity for teachers to participate actively and collaboratively in professional communities is an essential component of high-quality PD. By engaging teachers as active participants, PD providers acknowledge that learning is an active process wherein learners construct new understandings based on what they already know and believe. PD experiences are particularly effective when teachers participate in developing the learning opportunities, and work collaboratively to inquire and reflect on their practice."[Borko et al., 2010, p. 550]

Borko et al. also specify the way they suggest professional learning communities should work together: *"Respect and trust are important features of community development, enabling teachers to engage in discussions that are both supportive and challenging, and that maintain a balance between respecting individual community members and critically analyzing issues in their teaching."* [Borko et al., 2010, p. 550]

When describing the process and structure characteristics of high-quality PD it is of importance that PD activities "are ongoing and sustainable over time" [Borko et al., 2010, p. 550; also see Darling-Hammond and McLaughlin, 2011; Hawley and Valli, 2000; Knapp, 2003] and "provide the opportunity for teachers to engage in cycles of experimentation and reflection." (ibid.)

Despite the unity among U.S. PD experts on said qualities of a modern teacher training course, the empirical evidence regarding the effectiveness is scarce [Borko et al., 2010, p. 550;Knapp, 2003, p. 120]. Borko even goes so far as to state that "... research on teacher PD has been criticized for its limited scope and lack of scientific rigor." [Borko et al., 2010, p. 550].
The focus in U.S. research primarily lies in looking for initial evidence showing that a single PD program is beneficial to teacher learning. Already in 2004 Borko suggested "a three-phase research agenda for designing, implementing, and investigating scalable models of PD." [Borko et al., 2010, p. 551]

- **Phase 1** research projects look at PD at one site and tries to gain evidence that the PD program is practicable and improves teacher learning.
- **Phase 2** research projects build on top of phase 1 projects and extend them in order to determine whether or not a PD program is scalable.
- **Phase 3** research projects start relating several PD programs, held at multiple sites. These research projects among other things look at resource requirements and their impact on teacher and student learning.

(cf. ibid.)

A different angle

Though Borko's research agenda is certainly a promising step in the right direction, it does not seem to look at the most common aspects of all PD – the teacher. PD research is best advised not only to focus its research endeavours on the effects of specific PD programs but also to focus on the subject of the training itself – the teacher: As we have seen in subsection 3.1.2, there is empiric evidence for different subsets of vocational personalities with regards to the subject taught. Also research on what other forms of PD are currently being used by teachers might prove beneficial for any PD program. The group dynamic behaviour of teachers in groups of other teachers is likely to be important for many PD activities. A sensible way for PD research might be to find out as much about the clients (teachers in our case) as possible and to incorporate this knowledge in the design of the PD program. As many PD programs have shared aspects it might prove beneficial to pool research on those common aspects. For instance, formal PD often will involve teachers meeting for the first time or it involves teachers collaborating in smaller groups or pairs. Often teacher trainings will have informal spaces inside (e. g. coffee-breaks) that in terms of group-dynamics might deserve attention of any PD research. The research of this work thus would fall into this type of client-oriented research.

CHAPTER 5

THE CAT PROJECT

This chapter gives background information and a detailed description of the science teacher training that the field data was gathered in. This will improve the reader's understanding of the formal as well as informal setting and will point out some possibly relevant factors for the recorded conversations.

5.1 Development of the CAT science teacher training course

In 2008 the call for projects in the Lifelong Learning Programme (LLP) included the notion that

"[...] there is a need to promote and reinforce teachers' skills and knowledge to make best use of the new opportunities created by digital educational content and services of all types, [. . .]. Projects should focus on the development, testing, and implementation of materials, courses, and new pedagogical methods designed to improve the use of good quality digital content in teaching in schools, [. . .]" [European Commission DG Education and Culture, 2008, p. 9].

Indeed a 2004 OECD survey had found out already, that the use of information and communication technologies (ICT) in most countries concentrated on sporadic information retrieval from the internet [OECD, 2004]. Additionally, the use of computers and the use of internet in schools inside Europe had been analysed by the Head Teacher Survey (HTS) and the Classroom Teacher Survey (CTS) in 2006 as part of the Lisbon strategy and i2010 [ECI, 2006]. The report could show that 30.5% of science, mathematics and computer science teachers inside the EU 25+2 agreed or strongly agreed, that existing teaching materials on the Internet were of poor quality [ECI, 2006, p. 359]. 37.8% of science, mathematics and computer science teachers inside the EU 25+2 agreed or strongly agreed, that it was hard to find adequate learning material for teaching [ECI, 2006, p. 374]. And 41.1% of science, mathematics and computer science teachers inside the EU 25+2 agreed or strongly agreed, that teachers at their school did not have sufficient computer skills [ECI, 2006, p. 364].

This problem in mind the Department of Physics of the Heidelberg University of Education formed an international consortium of science researchers, teachers and teacher-trainers and applied for the Comenius Lifelong Learning Programme (LLP)[1] successfully. The consortium brought together the collaborative efforts of seven partner institutions out of six different nations.

1. University of Education Heidelberg, Germany
2. University of Helsinki, Finland
3. Institut Français De L'Éducation (ifé), France [2]
4. University of Education Schwaebisch Gmuend, Germany
5. University of Patras, Greece
6. University of Plovdiv "Paisii Hilendarski", Bulgaria
7. University of Vienna, Austria

The project was granted and became a funded Comenius project under the title: *"The effective use of Computer Aided Teaching and learning material in science teaching – a teacher training course with a European perspective (CAT)"*[3]. Its main purpose was the creation of "teaching modules for a teacher-training course, which enables teachers to consider the quality of computer aided learning environments in science teaching, to adapt best-practice examples of those environments to their own teaching, and to evaluate their own teaching afterwards." [Welzel-Breuer et al., 2010c, p. 7]. In the following three years the international consortium worked together to develop a modular in-service teacher training course that focused on three different topics:

[1] The Comenius LLP, an EU funded project aiming at improving the quality of lessons, strengthening the European dimension and increasing mobility through promotion of training and further training of teachers, school partnerships and school networks, had a life span from 2007–2013.

[2] Formerly known as Institut National de Recherche Pédagogique and University of Lyon 2.

[3] Grant Agreement number 141767-LLP-1-2008-1-DE-COMENIUS-CMP.

- **Module 1:** defining criteria for choosing usable Computer Aided Teaching and learning material (CAT) for science teaching and learning.
- **Module 2:** devising ways and methods of implementation of Computer Aided Teaching and learning material (CAT) in science classes.
- **Module 3:** implementing self-evaluation of own teaching with Computer Aided Teaching and learning material (CAT) through Action Research [see Altrichter et al., 2008].

The idea of the consortium was to create a teacher training course "à la carte" in which the participating teachers themselves could pick the module they wanted to professionalize in. This was done "to meet as direct as possible the needs of the participants" [Welzel-Breuer et al., 2010c, p. 26]. The conception of the course modules back then was influenced by an OECD survey from 2004 [OECD, 2004] as well as from the already mentioned HTS and CTS surveys from 2006. Because of the overaged data, the consortium decided to construct and implement a survey specifically to receive up-to-date data, which then could be used for the design of the consortium's science teacher training course. The survey took up ideas from the OECD survey from 2004 and tried to update relevant data from HTS and CTS on the current ICT situation in schools within the consortium's participating countries. The survey reached 854 science teachers from six countries [Welzel-Breuer et al., 2010b]. Among the findings of the survey was a noticeable difference between the estimated self-competence in Information and Communication Technologies (ICT) of male science teachers and of female science teachers: Women estimated their self-competence 20–30% lower [cf. Welzel-Breuer et al., 2010b, p. 7]. The science teachers within the survey also were asked to rank and set items according to their preference for a course or a workshop. The items preferred turned out to be the following:

1. Seeing best practice examples of implementation of computers inside the classroom.
2. Methods to effectively use the computer in class.
3. Getting to know specific software and tools for implementation in class.
4. Support for the choice of appropriate software for the use in science lessons.
5. Learning how to use the computer for preparatory work outside the classroom.

The survey also contained open questions that were meant to figure out underrepresented aspects in former science teacher training courses attended by the teachers. The answers were categorized and counted. Underrepresented aspects in former courses attended by teachers were:

1. Training on school premises (with all constraints).
2. Ready to use lessons and ready to use material (based on real situations at school).
3. How to use ICT in specific subjects / topics.
4. Longer courses with long term guidance.
5. Creation of educational material (webpages, animations).

[Welzel-Breuer et al., 2010b, p.7]

These results showed that science teachers were able to communicate their ideas of a successful intervention rather clearly. The science teacher training course was finalized in 2010 and a handbook for the training course published under the title *"The Effective Use of Computer Aided Teaching and Learning Material in Science Teaching"* [Welzel-Breuer et al., 2010c]. The course tries to pick up on the aspects teachers felt underrepresented in previous teacher training courses attended and thus is conceptualized as a blended learning course [see Graham, 2006; Häfele and Maier-Häfele, 2010; Reinmann, 2008] that includes two online distance learning phases. The first online distance learning phase was designed as a preparatory module implemented via the learning management system (LMS) Moodle. Over a course of two months course participants had to work on multiple units, in which they had to (virtually) hand in work, which then was reviewed by trainers. The course modules by design also included encouragement for the teachers, to get to know each other more over the internet. The second online distance learning phase was placed after a week of intensive course work in the real world and should allow for a smoother transition of acquired content into practice at school – it was scheduled for a duration of a little more than a month. As already mentioned in between these two online phases the course conceptualised a one week-long training on site where the participants could meet face to face and engage in some practical course work following their modules. This so called face-to-face meeting is planned as an integral part of the whole training, here *"[...] the teachers have the possibility to meet teachers from other European countries, they can install own teacher networks and partnerships, they can find professional friends, and they will experience new approaches,* *technologies and material."* [Welzel-Breuer et al., 2010a, p. 26]. The first and second module are planned for an overall duration of about three months the third module is organized to take about five months. It was the original intent of the course's design to have the participants of the first two modules to be able to meet each other in the breaks and off-course-work-phases of the face-to-face meetings. This was planned to foster the informal exchange between participants of different modules about the content of these modules. The idea being that the different experiences during the course times could act as a natural conversation starter inside informal settings thus increasing the chances for informal learning.

The Comenius LLP project CAT had been brought to conclusion with the publication of a complete course design by the end of 2010.

5.2 Realization of the CAT4U teacher training course

After three years of development the consortium decided to seek implementation of the course and published all three course modules in the Comenius and Grundtvig training database. The Comenius and Grundtvig training database[4]

"[...] contains information about in-service training courses, seminars and conferences offered in Europe for teachers, teacher trainers and non-teaching staff involved in school education (from pre-primary up to upper secondary) or adult education. All training events are for a European audience and their overall objective is to help participants upgrade their professional skills in the field of education. The events are organized by various training providers who submit their training offers to the National Agencies of the Lifelong Learning Programme, set up in all the participating countries. Costs of participation in the training events can be supported with Comenius In-Service training for Teachers and other Educational Staff grants [...] for which interested people should apply to their respective National Agencies [...]" [COMM/DGEAC/E4, 2003]

Teachers primarily were interested in course module two and so the consortium decided to only implement this module and organized an independent course containing only one module. The course was called *"CAT4U: Effective Use of Computer Aided Teaching and Learning (CAT) Materials – Ways and Methods of Implementation of CAT Materials in Science Classes (Module2)"* As location for the training the city of Patras Greece was selected. The course started with the first distance learning phase on 1st February 2011 on the learning platform

[4] See http://ec.europa.eu/education/trainingdatabase/ the database ceased operations in June 2014 soon after the official end of the LLP.

Moodle.[5] The distance learning phase ended on 26th March 2011. By that time, the participants had incidentally collaborated via the Moodle platform, had introduced themselves to each other virtually and had started to plan their trip to Patras as well as selected their accommodation throughout the week together in different groups via a Wikiversity page.[6] In planning they received support from the Greek trainers.

On Sunday 27th March 2011 the participants arrived in Patras and spent a welcome evening together. On Monday 28th March the face-to-face phase of the teacher training course officially started and went until Friday 1st April 2011. The five work days roughly shared a similar structure:[7] From 8–12 o'clock a session, followed by a break for lunch and social networking from 12–14 o'clock and finally a second session from 14–18 o'clock. Each session was divided into a lecture part and into a group work part. The evening was scheduled for sightseeing. After the face-to-face week, the second distance learning phase was held via the LMS Moodle stretching from 3rd April 2011 to 8th May.

[5] Moodle Version 1.9.10.

[6] See section 5.3 for more. Website at https://en.wikiversity.org/wiki/CAT4U_Patras_Journey.

[7] See the full schedule of the F2F-week at page 97.

Table 5.1 Face to Face Meeting: March 27 to April 2, 2011 in Athens (Greece) organized by University of Patras Saturday the 26th meeting at Plaka and dinner together. Schedule for the Face-to-Face Meeting

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Time	March 27	March 28	March 29	March 30	March 31	Apr 01
08–10	Excursion to Epidaurus – Nauplion	Introduction	Primary school visit	Best Practice examples	How to organize the classroom (3) Intro + Group work	How to organize the classroom (4) Intro + Group work
10–12		Introduction into Module			Presentation and discussion of GW	Presentation and discussion of GW
12–14		Lunch	Lunch	Lunch	Lunch	Lunch
14–16	Arrivals	The future and its impact in the use of ICT in education	The future and its impact in the use of ICT in education	How to organize the classroom (1+2)	How to organize the classroom (4) Intro + Group work	Online phase preparation
16–18	Arrivals			Presentation and discussion of GW	Presentation and discussion of GW	Evaluation/ Feedback
18–20		Walk to Achaia	Walking Tour at Patras with part of the participants.	Tour to Naupaktos		
20–22	Get together	Welcome dinner Achaia Beach	Walking Tour at Patras with part of the participants.	Dinner at Naupaktos with part of the participants.	Official Farewell dinner Camping Rion	Trip home, (informal farewell dinner at Plaka)

5.3 Relevant contacts of participants before the beginning of the course week

As already mentioned, the course participants had worked together on online course material from 1st February to 26th March 2011. The online course consisted of weekly tasks that had to be taken inside of a Moodle Learning environment. Some of the tasks also contained exercises that encouraged the participants to learn more about each other. The engagement in the online course was heterogeneous while the online course was embraced by most, some of the participants only engaged sporadically or even not at all.

Organizing the course and placing it on the Comenius teacher training database for teachers to apply for the training had a somewhat decentralizing effect for the organization of the journey. Since the participants received their entire funding including course fee and travel expenses through their national agencies (see page 95) we were in the position of broking travel information rather than organizing the journeys for the participants ourselves. This circumstance lead to the creation of a self-organisation website, implemented through an open Wikiversity[8] page by us. We started the page with a very simple structure and tried to aggregate and to structure the discussion, which unfolded simultaneously within online chat inside the learning platform Moodle. Going through the WIKI's changelog files[9] we can see, that once we put a call for action on the WIKI and introduced a section inviting active participation, the engagement in the WIKI took a remarkable turn of events with participants and trainers taking ownership of their journey and assuming control of concrete organizational matters. Under the section "What can you do?" we suggested the following

- List the hotels where you will be staying before / during / after your visit to Patras.
- If you want to hire a car, please put this into the WIKI.
- Think about the places you could visit on your trip to Patras and put them in the section.
- If you have another topic you consider important for the journey, please feel free to add new sections.

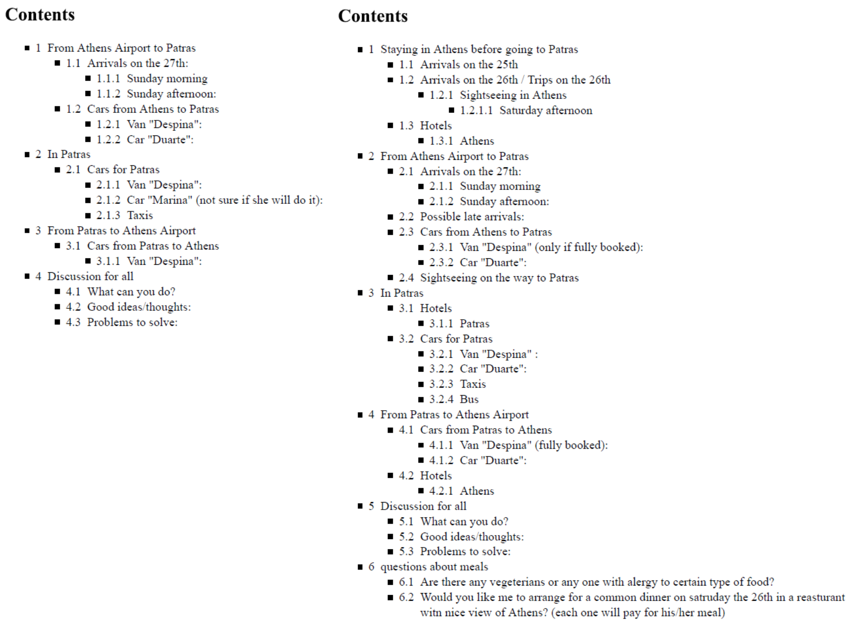
[8] Wikiversity is a project by the Wikimedia Foundation supporting learning communities, their learning materials and resulting activities (see https://en.wikipedia.org/wiki/Wikiversity).

[9] A chronological record of changes applied to the WIKI page open to inspection at https://en.wikiversity.org/w/index.php?title=CAT4U_Patras_Journey&action=history.

The participants as well as the trainers reacted and extended the WIKI towards a direction we originally had not thought of ourselves (see figure 5.1): They added the sections

- “Staying in Athens before going to Patras” with their respective subsections,
- “Arrivals on the 25th”,
- “Arrivals on the 26th / Trips on the 26th” with the subsubsection
- “Sightseeing in Athens” and
- “Saturday afternoon”.

Also included was a section regarding hotels in Athens, another section on “Sightseeing on the way to Patras” and “Hotels” in Patras and finally also one regarding the dietary needs and preferences of the participants. By posing simple organizational questions like “Where are you staying before flying back home?” participants were given the opportunity to participate and at the same time use the information given for their own purposes.


Contents

- 1 From Athens Airport to Patras
  - 1.1 Arrivals on the 27th:
    - 1.1.1 Sunday morning
    - 1.1.2 Sunday afternoon:
  - 1.2 Cars from Athens to Patras
    - 1.2.1 Van "Despina":
    - 1.2.2 Car "Duarte":
- 2 In Patras
  - 2.1 Cars for Patras
    - 2.1.1 Van "Despina":
    - 2.1.2 Car "Marina" (not sure if she will do it):
    - 2.1.3 Taxis
- 3 From Patras to Athens Airport
  - 3.1 Cars from Patras to Athens
    - 3.1.1 Van "Despina":
- 4 Discussion for all
  - 4.1 What can you do?
  - 4.2 Good ideas/thoughts:
  - 4.3 Problems to solve:

Contents

- 1 Staying in Athens before going to Patras
  - 1.1 Arrivals on the 25th
  - 1.2 Arrivals on the 26th / Trips on the 26th
    - 1.2.1 Sightseeing in Athens
      - 1.2.1.1 Saturday afternoon
  - 1.3 Hotels
    - 1.3.1 Athens
- 2 From Athens Airport to Patras
  - 2.1 Arrivals on the 27th:
    - 2.1.1 Sunday morning
    - 2.1.2 Sunday afternoon:
  - 2.2 Possible late arrivals:
  - 2.3 Cars from Athens to Patras
    - 2.3.1 Van "Despina" (only if fully booked):
    - 2.3.2 Car "Duarte":
  - 2.4 Sightseeing on the way to Patras
- 3 In Patras
  - 3.1 Hotels
    - 3.1.1 Patras
  - 3.2 Cars for Patras
    - 3.2.1 Van "Despina" :
    - 3.2.2 Car "Duarte":
    - 3.2.3 Taxis
    - 3.2.4 Bus
- 4 From Patras to Athens Airport
  - 4.1 Cars from Patras to Athens
    - 4.1.1 Van "Despina" (fully booked):
    - 4.1.2 Car "Duarte":
  - 4.2 Hotels
    - 4.2.1 Athens
- 5 Discussion for all
  - 5.1 What can you do?
  - 5.2 Good ideas/thoughts:
  - 5.3 Problems to solve:
- 6 questions about meals
  - 6.1 Are there any vegeterians or any one with alergy to certain type of food?
  - 6.2 Would you like me to arrange for a common dinner on satruday the 26th in a reasturant witn nice view of Athens? (each one will pay for his/her meal)

Figure 5.1 Left: Table of Contents Draft by CAT4U - Team | Right: Table of Contents Final Version by Participants and Trainers

The WIKI page seemingly not only became a source for information relevant for travel from the Greek trainers but also became a tool for organizing as well as synchronizing the trip across all participants. The exact mechanisms at play bringing the participants to invest themselves in the organization of the journey of course cannot be retraced in detail. However, we believe this virtual contact and the planning might have led to a more active atmosphere in which participants seemed to be more willing to participate and to take matters into their own hands. This is why we tried to look for possible explanations for the effect encountered rather accidentally in our science teacher training.

5.3.1 Relevance of the WIKI-Incident for PD

The growth of the WIKI and the planning sparked by the stimulated communication lead participants to cooperatively engaging in planning their own trips to Patras themselves including hotel bookings, carpools and sightseeing trips. We were surprised to see how quickly participants took matters into their own hands. According to Deci & Ryan's self-determination theory (SDT) we might have tapped into motivational aspects regarding autonomy (planning their own routes to Patras), competence (using the Wiki-page and organizing the trip) and relatedness (carpools, hotel bookings with other participants, anticipation of collaboration). We also believe that this experience might have been an important cornerstone of setting the tone for the whole teacher training as a “listening science teacher training” – not merely imparting knowledge but being open, flexible and reactive towards the needs of its participants. This general feeling however, cannot be substantiated by specific data other than the recorded conversations themselves – and one can find references within the conversations referring to the journey having had a special atmosphere and possibly having had a special influence on the bonding between individuals.[10]

Trying to understand some aspects of the WIKI-Incident we decided to look at it from a motivational perspective: What are possible motivations on the part of the participants?

Deci and Ryan speak of perceived competence when people feel ownership of the activities they engage in and when they perceive them as self-organized [Ryan and Deci, 2017, p. 95]. We believe, that the circumstances of the funding and the need to organize one’s own trip created just the ownership Deci & Ryan refer to: A subset of the Self-determination theory is the Cognitive Evaluation Theory (CET) which is focused exclusively on intrinsic motivation [Ryan and Deci, 2017, p. 123]. The core of CET can be summarized in the following way:

> *“CET argues that events that negatively affect a person’s experience of autonomy or competence will diminish intrinsic motivation, whereas events that support perceptions of autonomy and competence will enhance intrinsic motivation. The theory further argues that both competence and autonomy satisfactions are necessary to sustain intrinsic motivation.”* [Ryan and Deci, 2017, p. 124]

Inside the CET Deci and Ryan in the 1980s introduced an idea based on the concept of the perceived locus of causality (PLOC) introduced much earlier by Heider and de Charms [de Charms, 1968; Heider, 1958]. The PLOC – the perceived locus of causality differentiates the view any person has upon the cause of their own action: Does the person believe that they acted out of an internal motive their intrinsic motivation tends to be higher. However, if the person believes that the causality of their action was external, their intrinsic motivation tended to be lower. Deci and Ryan believed that a person’s perception of why they were doing something (PLOC) could be intentionally or unintentionally influenced

[10] We will take a look at the possible group formation aspects of the journey later in the sociometric part of the work.

by external factors – and thus could be shifted from an internal perceived locus of causality (I-PLOC), associated with intrinsic motivation towards an external perceived locus of causality (E-PLOC), associated with diminishing intrinsic motivation [Ryan and Deci, 1980, 1985]. CET consequently introduced the following propositions:

1. *"**CET Proposition I:** External events relevant to the initiation or regulation of behavior will affect a person's intrinsic motivation to the extent that they influence the perceived locus of causality for the behavior. Events that promote a more external perceived locus of causality or have a functional significance of control will thwart autonomy and undermine intrinsic motivation, whereas those that promote a more internal perceived locus of causality will increase feelings of autonomy and enhance intrinsic motivation.*

2. ***CET Proposition II:** External events will also affect a person's intrinsic motivation for an activity to the extent that the events influence the person's perceived competence at the activity. Events that promote greater perceived competence enhance intrinsic motivation by satisfying the person's need for competence. Events that meaningfully diminish perceived competence undermine intrinsic motivation.*

3. ***CET Proposition III:** External events relevant to the initiation and regulation of behavior have three aspects, each with a functional significance. The informational aspect, which conveys information about self-determined competence, facilitates an internal perceived locus of causality and perceived competence, thus supporting intrinsic motivation. The controlling aspect, which pressures people to think, feel, or behave in particular ways, facilitates an external perceived locus of causality, thereby diminishing intrinsic motivation. The amotivating aspect, which signifies incompetence to obtain outcomes and/or a lack of value for them, undermines both intrinsic and extrinsic motivation and promotes amotivation. The relative salience of these three aspects for the person, which can be influenced by factors in the interpersonal context and in the person, determines the functional significance of the event, and thus its impact on intrinsic motivation."*

[Ryan and Deci, 2017, pp. 129–130]

We believe that through the relatively open structure of planning the journey, and their need to organize the trip for themselves, the non-mandatory, open informational structures we provided were regarded as an optional tool for self-organization rather than a tool of external control. This might have been fostered by two crucial factors:

1. The organization of the journey including the funding and personal decisions (e.g. whether or not to rent a car, which hotel to reside in etc.) possibly increased the ownership of the trip. Every decision thus remained as having an I-PLOC.

2. Instead of asking or forcing the participants to send their travel information, the presentation of an optional open tool, that allowed for information as much as it allowed for self-organisation possibly also increased the perception of an I-PLOC.

These two factors in theory keep up a more I-PLOC resulting in a better condition for intrinsic motivation. Deci and Ryan in general stress the importance of choice for an I-PLOC:

"[...] a meta-analysis by Patall, Cooper and Robinson (2008) of 41 such studies examined the effect of choice on intrinsic motivation and related outcomes in both child and adult samples for a variety of behaviors. Results strongly indicated that providing choice enhances intrinsic motivation, as well as related variables such as effort, task performance, and perceived competence, among others." [Ryan and Deci, 2017, p. 151]

It is unclear whether elements of the CET that in our case supposedly referred to the organisational parts of the CAT science teacher training course have the power of positively influencing learning inside (science) teacher trainings. We assume, that the more aspects of a (science) teacher training are opened to elements of codetermination and suggest for participants to take ownership thus allowing for more I-PLOCs on the side of the participants to occur the more this might encourage a culture of active involvement and participation that may influence learning. Further research in this field is recommended.

Chapter 6

Research questions

In chapter one we presented the reader with some logical reasoning regarding the potential significance of the field in general and also presented ideas why we believe that research in this field might present a pivotal point in increasing science teacher quality and student learning. However, it became obvious, that the field (consisting of multiple interrelated fields) we are focusing on in its very nature is vast: It spans from looking at the whole system of science teacher professionalization in all phases and understanding it as a continuous, complex and lifelong process, over understanding more of teacher's career cycles, to looking at all professionalization activities science teachers participate in and reflecting on the way, that they are or might be working together in an efficient manner. As we have seen the whole field of PD also is as much dependent on external factors such as educational policy as it is influenced by systemic forces active inside the institution school itself and containing strong sociological implications.

Due to the strong bearings of each of the different facets on future concepts of science teacher trainings, course developers will need to reflect on all these entirely different levels simultaneously.

Every journey has to begin with a first step, in our case this is a step of close observation and critical reflection on the level of science teacher training courses. In 2011 we had the chance of organizing an international science teacher training course, which had been previously created in a three-year long Comenius project by an international consortium including the University of Education Heidelberg (Germany), the University of Vienna (Austria), the University of Plovdiv (Bulgaria), the University of Education Schwäbisch-Gmünd (Germany), the University of Helsinki (Finland), the National Institute for Educational Research (France), the University of Patras (Greece) (for more on the course turn to chapter 5). The training presented us with an interesting opportunity: Most of the participating science teachers had never met before in real life. Through the blended learning structure of the course they had virtually met in an online part of the course and would meet face-to-face for the first time in Patras, Greece. In analysing the informal conversations of the course participants, we hope to understand more of the ways that science teachers connect on an international science teacher training. Analysing their informal conversations also allows for insight in the ways that teachers exchange about profession related content among themselves. This is especially relevant in terms of determining ways and methods to effectively connect to teachers and also in understanding more of the thinking of practitioners.

As already seen before, TALIS results clearly state that informal conversations improve teaching (2008: 92,6%/2013: na) as well as courses and workshops (2008: 81,2%/2013: 71%) were the most frequently given answers, when teachers were asked regarding professional development activities undertaken in the last 2008:18/2013:12 months [OECD, 2010; Table 4.8 OECD, 2014c, p. 103]. By looking at and understanding the ways teachers communicate inside a training, in the long run we might be able to create teacher trainings that are able to add extra layers of PD inside training courses and even foster synergies between different PD activities for science teachers beyond the realm of the training itself. In the first stage of research we want to inquire whether informal dialogue to improve teaching also took place inside a formal science teacher training course and if so in which way? We also want to look at the way teachers connected with each other throughout the course week trying to find patterns in the way that science teachers who had never met before made contact in a science teacher training course and established their relationships towards each other.

After analysing those conversations, we will try to bring as many of the knowledge gathered on science teachers together and reflect on them in order to draw well-founded conclusions on how to sensibly design teacher training courses with regard to the hypotheses formed from looking at the communication processes in our sample. As we are convinced that PD is subject to many influences at once, we are determined to approach our conclusions in a holistic manner. This means that our reflections will try to take the status quo seriously, while at the same time thinking about and pointing to important factors that might be worth contemplating when looking at ways and means of improving the overall situation PD is in. Taking into account relevant scientific results from related disciplines will constitute an essential part of this endeavour.

Our research questions for this work are:

1. In how far do teachers use the possibilities of international and intercultural informal communication within the CAT course, with regard to teaching and learning science?
   (a) What are the contents/topics addressed in the communication processes?
   (b) On what occasions environments did subject related conversations occur?
2. How precisely does the communication between the international participants of a blended-learning course for the use of ICT in science education evolve?
   (a) Which kind of patterns or phases regarding the informal communication can be detected?
   (b) How does the creation/development of a group structure look like in the light of a sociometric analysis? Are there signs inside the analysis that can be connected to a sustainable formation of groups beyond the lifetime of the project?
3. What reasonable well-founded conclusions can be drawn from looking at the analysis of the informal conversations and considering the knowledge we have about PD in general and effective teacher training courses in particular also taking account of related fields?
   (a) What is the current knowledge regarding teacher professionalization in general and effective teacher training courses in particular and how might informal contexts be adequately implemented?
   (b) What results from neighbouring social sciences are of relevance to draw conclusions from?
   (c) Which factors seem relevant for the design of modern teacher training courses?

CHAPTER 7

METHODOLOGY

In this chapter we will describe our methodology for answering the research questions presented in the previous chapter.

7.1 Research question 1

Research question 1 reads as follows:

1. In how far do teachers use the possibilities of international and intercultural informal communication within the CAT course, with regard to teaching and learning science?
   (a) What are the contents/topics addressed in the communication processes?
   (b) On what occasions environments did subject related conversations occur?

7.1.1 Transcription

In order to answer the research question one, we made use of the audio recordings gathered during the face-to-face week (see chapter 2). The audio-material was taken and transcribed by a team of four people using the software "F4"[1]. Two of the three external persons hired for creating transcripts received a three-hour training to be able to reliably discern the voices heard on the audio recordings and to attribute every speaker in the software in a suitable manner. One person

[1] The software "F4" by audiotranskription.de was used from "F4plus" in version v.5.01.9 to "f4transkript" in version 6.2.5 Pro.

received the training via voice samples and a one-hour instruction into the use of the software “F4”. The method of collecting informal conversations by means of audio-recording devices is not without fault – sometimes the recordings are distorted or the voices on the recordings too low to properly understand them. At other times, there are too many speakers on the recording to figure out, what exactly was said[2] and what was said to whom, sometimes it is hard to find out who said it. Fortunately, these unfavourable conditions for transcription rarely occurred. For the most common situations the hired staff could identify teachers and trainers reliably. The transcription of the informal conversations was performed using the following transcription rules adapted from Mayring [Mayring, 2010, p. 55].

- Transcriptions are complete and literal as far as they are comprehensible. Incomplete structures and repetitions remain.
- Dialectic pronunciations will be put into plain German/English. Single dialectic expressions remain. Statements in other languages than German or English (e.g. Finnish, Bulgarian, Greek) are marked as such (e.g. “(speak Greek)”). Parts in languages other than English or German are thus not included into thematic codings.[3]
- Incomprehensible parts are marked (incomprehensible).
- The speakers turns are marked in the following ways:
  - “–D.” for unique initials.
  - “-Despos” or “-Desp.” for non-unique initials.
- Interruptions in speaker’s turns are marked with “//”.
- Uncertain speakers inside the transcriptions are marked with “(?)”.
- Conversations in the background happening at the same time and distinguishable from the conversation closer to the recorder are transcribed marked with “(in the background)”.
- Conversations picked up by the recorder roughly the same quality are marked with “(parallel talk)”.
- Conversations happening at the same time but being incomprehensible are left out without special identification marks.

[2] This includes conversations happening at the same time.

[3] Unfortunately, the author did not have access to fluent speakers of said languages.

- Pauses in speech are marked with "(.)" "(..)" or "(...)" – the number of dots in the brackets representing the length of the pause roughly in seconds.
- Laughter is marked "(laughs)". Saying something under laughter is marked "laughing".
- Words that are particularly stressed by the speaker are written in capital letters. Example: "FOUR".
- Transcriptions are split into sections or paragraphs marking units of conversation which each refer to either different strands of conversation or sense units.

A majority of the F4 - transcripts were loaded into the software MAXQDA 10.[4] In MAXQDA 10 the conversations were coded using an inductively developed code system for the topics addressed as well a standard code system for speaker, time and place (see chapter 7.1.2) and later ported into MAXQDA 11[5] and later ported into MAXQDA 12. Some F4 transcripts were imported in MAXQDA 12[6] and merged with the existing texts and finally coded using the previously developed code system.

7.1.2 Qualitative Content Analysis

A suitable scientific method for a quantitative analysis of qualitative material is the Qualitative Content Analysis. The Qualitative Content Analysis is a theory-based method, that aims at analysing texts by means of quantitative as well as qualitative techniques [see Mayring, 2010, p. 51]. In recent years powerful software tools have been developed, which allow to assist in analysing larger data sets [Kuckartz, 2014, p. 132].

In our research the use of Qualitative Content Analysis aims at a quantitative analysis of qualitative data [see Kuckartz, 2014, p. 15]. With regards to research question one we want to know, in what frequency did teachers (and trainers) address which topics throughout the informal spaces of the science teacher training at hand. In order to do so, we will inductively build a code system from all informal conversations that were recorded during the CAT teacher training. This inductively created code system will serve as a basis for a quantification of informal conversation topics. For our research question it is crucial to look at the conversations with an open mind and no prefabricated structural bias: This is

[4] MAXQDA is a software for qualitative data and text analysis. For the steps described it was used in Version R240113 including updates until MAXQDA 11.

[5] Version Release 11.0.11 including updates until MAXQDA 12.

[6] Version 12.3.2.

why we opted for the inductive formation of categories. The inductive qualitative content analysis deliberately desists from referring to theoretical perspectives before the completion of the formation of categories [see Mayring, 2010, p. 67 and 83ff.]. Due to the potential benefits of crossing several different sets of data for more complex computer analyses, the development of the category system was extended to include:

1. Categorization of situational aspects.
   (a) Categorization of speakers.
   (b) Categorization of time and context (location and situation).
2. Categorization of topic.

The first two subcategories are determined by the recorded material and the circumstances it was recorded in. They are in most cases not subject to interpretation. The third category however often consists of multiple layers of meaning and requires a procedure leading to a topic-related and accurate code system. After the creation of the topic-related code system an intercoder-reliability check is implemented.

Different means of coding in MAXQDA

Before describing the chosen research cycle for research question one and focussing on the development of the topic based code system, we will briefly describe the way that the situational data was coded inside MAXQDA and thus describe the contextual and time-based codes. There are essentially three ways to store code-information inside MAXQDA and use them to analyse data. In our research we used the following ways:

Table 7.1 Stored Code Information inside MAXQDA

	in code system	in document variable	in code variable
Categorization of speakers	✓	X	X
Categorization of time and context [Location & Situation]	✓	✓	X
Categorization of topic	✓	X	X

The code system is applied to the transcribed texts ad hoc, while the document codes allow every recording to receive additional tags that serve as additional descriptors for each recorded document. Code variables allow specific codes to be tagged with additional descriptive elements, that allow each coding to be differentiated further.

As can be seen from table 7.1 the categorization of time and context was done twice. We started by coding time and context (situation and location) as situational codes parallel to the speaker and the topic code system. As algorithmic calculations across the code system inside MAXQDA for analytical purposes proved to be too time-consuming, it was decided to convert the codes for time as well as for context (situation and location) into Document variables: Each recorded document received a time-related, situation- and location-based variable that (de-)activated the document when a certain variable was selected for analytical purposes. The time graticule was converted from a code system based one-hour interval into a more simplified grid:

Table 7.2 Document Variables for time-based analysis

Morning	Afternoon	Evening	Late Evening
08:00–11:59	12:00–17:59	18:00–22:59	23:00–01:30

This time grid was developed – starting from a 6h-based interval, and adapting it to the realities of available recordings [7] and a reflection of some chronobiological factors: The begin of the late evening was determined by sleep onset according to Lack and Wright [2007, p. 1205] beginning at about 23:00.

Additionally to the time of day, the day of the week was also added in the form of a document variable (e.g. Monday, Tuesday etc.) that each recording took place in. The Contextual document variables were the following:

[7] There are no recordings prior to 08:00 or after 01:30.

Table 7.3 Contextual Document Variables used in MAXQDA

Contextual Document Variables	
Location	Situation
Bar	After Lesson
Conference Room	At the Vineyard
Hotel Restaurant	Before Lesson
Primary School	Breakfast
Restaurant	Dinner
University Hallway	En Route By Car or Van
Way to Food Place from Vineyard	En Route By Foot
Way to Hotel from Food Place	End of Session
Way to Hotel from Session	Farewell Dinner
Way to Lunch from Session	Inside Lesson
Way to Primary School from Hotel	Lunch
Way to Session from Hotel	Session
Way to Session from Lunch	Shouting in a wine barrel
Way to Vineyard from Primary School	Sitting together late at night
Vineyard	unclear
	Welcome Dinner

7.1.3 The development of the topic related code system

Inductive Qualitative Content Analysis requires the development of a code system that reflects the material at hand and the level of abstraction [see Mayring, 2010, p. 84]. The following procedure is the general cycle for the inductive form of the Qualitative Content Analysis suggested by Mayring [ibid.]:[8]

1. Material, targets of analysis, theory,
2. determination of selection and level of abstraction,
3. work through material / categorization of material,
4. revision of categories after 10-50% of the material [go back to i.],
5. final work through material,
6. interpretation, analysis.

[8]Translations by the author.

Mayring explicitly states that the inductive form “derives its categories directly from the material in a process of generalization, without relating to previously formulated theoretical concepts.” [Mayring, 2010, p. 83].

Like every research the scientific method of inductive Qualitative Content Analysis required the adaption of the general model cycle towards the goals of the research at hand. In this case several modifications to the general cycle were implemented to suit the needs of the project. The following is a depiction of the cycle that was used both for research question 1 and 2:

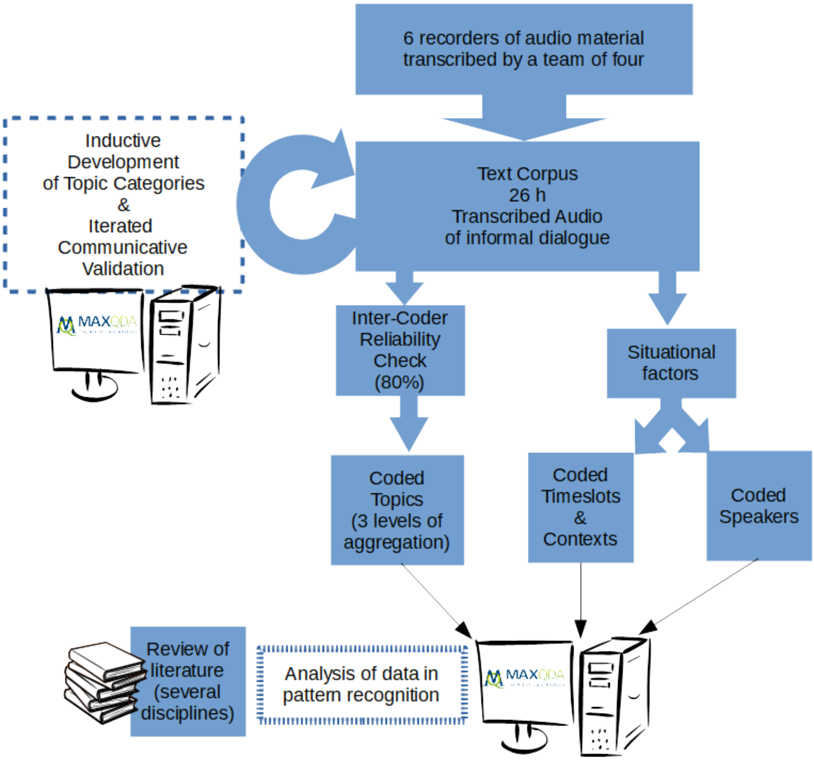


Figure 7.1 Research cycle for research question 1, 2 and 3

Instead of determining a selection, including a level of abstraction, the complete text corpus of transcribed audio material of all recorded informal conversations was coded directly inside MAXQDA 10 without the use of intermediate steps of selection or abstraction. The codes developed were applied, discussed, modified and then reapplied in an iterative process that refined the code system as it was developing. While using the codes, different levels of aggregation were implemented in order to structure the data and in order to find meta-topics in the form of main categories. At about 80% of the material was sufficient to contribute to the development of a nuanced and rather complete category system. The individual codes afterwards were aggregated into a system that comprised three levels of aggregation. The topic related main categories are labelled

- “Participants or Trainers”
- “Cultural”
- “Things happened on course”
- “Profession related”
- “Other Conversations”

A second line of categories referred to the already mentioned “Situational” aspects including their subcategories “Context”, with the subsubcategories “Location” and “Situation”, and the subcategory “Time”.[9] Speakers themselves were coded as a third branch under the situational codes. The complete category system is described in detail in subsection 7.1.4

Intercoder-reliability Checks

As stated above the revision of the categories was done multiple times over the material that had been coded so far. At roughly 80% of the total transcribed material the code system proved stable enough for intercoder-reliability checks.

The printout function of the software MAXQDA was used to printout the transcripts of several recordings into the PDF format, including their respective codings. The PDFs then were digitally redacted to contain the locations of coded segments, yet not the codings themselves. These redacted, unlabelled transcripts were then printed on paper in black and white and given to a person familiar with the code system. The inter coding partner was given the code system and was also instructed to apply the codes of the code system, to mark unclear segments and to suggest the introduction of additional codes when necessary. Coder A introduced a total of 3475 (2085) applied “topic codes” into the intercoder reliability check. Coder B reapplied and coded a total of (3513) 2123 “topic codes” of the same

[9] As mentioned before, although the situational categories were implemented in the code system, the situational categories were later converted into MAXQDA Document Variables.

code system. This represents between 81,3% (Coder A) and 82,8% (Coder B) of the complete coding of topic related codes in the entire project (2565 codes). A total of 3202 (84,57%) codes correlated. 584 codes had no correlation. The Cohen's Kappa was calculated to be:

Table 7.4 Intercoder Reliability Check – Cohen's Kappa

		Document 1		
		1	**0**	
Document 2	**1**	a = 3202	b = 273	3475
	0	c = 311	0	311
		3513	273	3786

P(observed) = Po = a / (a + b + c) = 0.85

P(chance) = Pc = 1 / number of codes = 1 / 66 = 0.02

Kappa = (Po - Pc) / (1 - Pc) = 0.84

In case of missing values or in case of comparing one code:

$P(chance) = Pc = numberofcodes/(numberofcodes+1)^2 = 0.01$

Kappa = (Po - Pc) / (1 - Pc) = 0.84

Landis and Koch suggest the following ratings for judging the agreement through Cohen's Kappa:

Kappa<0 = poor agreement
0<Kappa<0,20 = slight agreement
0,21<Kappa<0,40 = fair agreement
0,41<Kappa<0,60 = moderate agreement
0,61<Kappa<0,80 = substantial agreement
0,81<Kappa<1,00 = almost perfect agreement
[cf. Landis and Koch, 1977, p. 165]

The results of the intercoder reliability check showing a promising result we still decided to conduct a closer analysis of the intercoder agreement regarding code specific results. The analysis revealed the relative vagueness of 9 of the 66 codes:

Table 7.5 Vague Codes

Code	Correlates	Doesn't correlate	Total	Percent
Socialising	0	1	1	0
Well Being – Feeling well	4	4	8	50
Demanding	6	5	11	54,55
Recommendations	0	2	2	0
Getting personal	18	33	51	35,29
Ideas for the F2F week	2	2	4	50
Colleagues	0	3	3	0
Critical Thinking	0	2	2	0
Particular Interest	10	10	20	50

All codes that had proven to be too vague were either altered in their definition or dropped. Some of the codes were moved with regards to their aggregation levels to more poignant categories. New categories were also introduced during this process.

All 584 items that had been coded differently were discussed by Coder A and Coder B and the codes altered in a way that the intercoder-team agreed upon and thus validated through discourse.

7.1.4 Code System

The code system was constructed around two main categories that were called "topic" and "situational" each of the categories has several connected subcategories which again might contain subcategories of their own. The topic code system has been developed inductively using the transcribed conversations of the teachers as source material to abstract categories from. The codes were applied to the transcribed material in MAXQDA. Due to the complex nature of conversations in general, parts of the conversation could be attributed to multiple topic codes of different topic categories. The coding of multiple topic codes however was conducted only in the cases were both descriptions were deemed equally fitting. During the development of the topic codes – the whole material was iteratively worked through time and again and the codings adapted to adhere to the new category system, upon each introduction or alteration of any category. Having worked through about 80% of coding the material, the category system was not subject to further extension and proved to be adequate to describe the raw data. An intercoder-reliability check was implemented (see page 116 in the previous subsection 7.1.3) resulting in a Cohen's Kappa of 0.84. The deviations in codings that presented themselves inside the intercoder-reliability checks were discussed and finally resulted in a more pronounced formulation of descriptions of the topic categories. The definitive version of the topic code system was then applied to the material again.

The situational code system relies on basic contextual information of the material that in general could be coded without interpretation such as location, date, time and speakers. The general situation the speakers were in was also coded. In some rare cases the quality of the audio posed some difficulties with regard to attributing the spoken word to the right speaker.

The situational code system primarily serves as an aid to the analysis of the material. It allows to quantify the topics according to speakers, days of the week, times of the day, location or situations. It thus helps to create profiles of speakers, look for patterns of topics regarding special times of day or looking for changes in the nature of topics throughout the week. Also, the situational data can be used as source material for a sociometric analysis based on preferred conversational partners.

Description of Code System

This following section will describe the topic categories in our code system and explain how the categories are distinguishable from each other. The “Topic” category is split into six main categories also called Level One Categories. These categories in turn are split into subcategories referred to as Level Two categories. Some yet not all of these subcategories are branching into subsubcategories called Level Three categories. The following figures (7.2 and 7.3) are giving a structural overview of the topic code system:

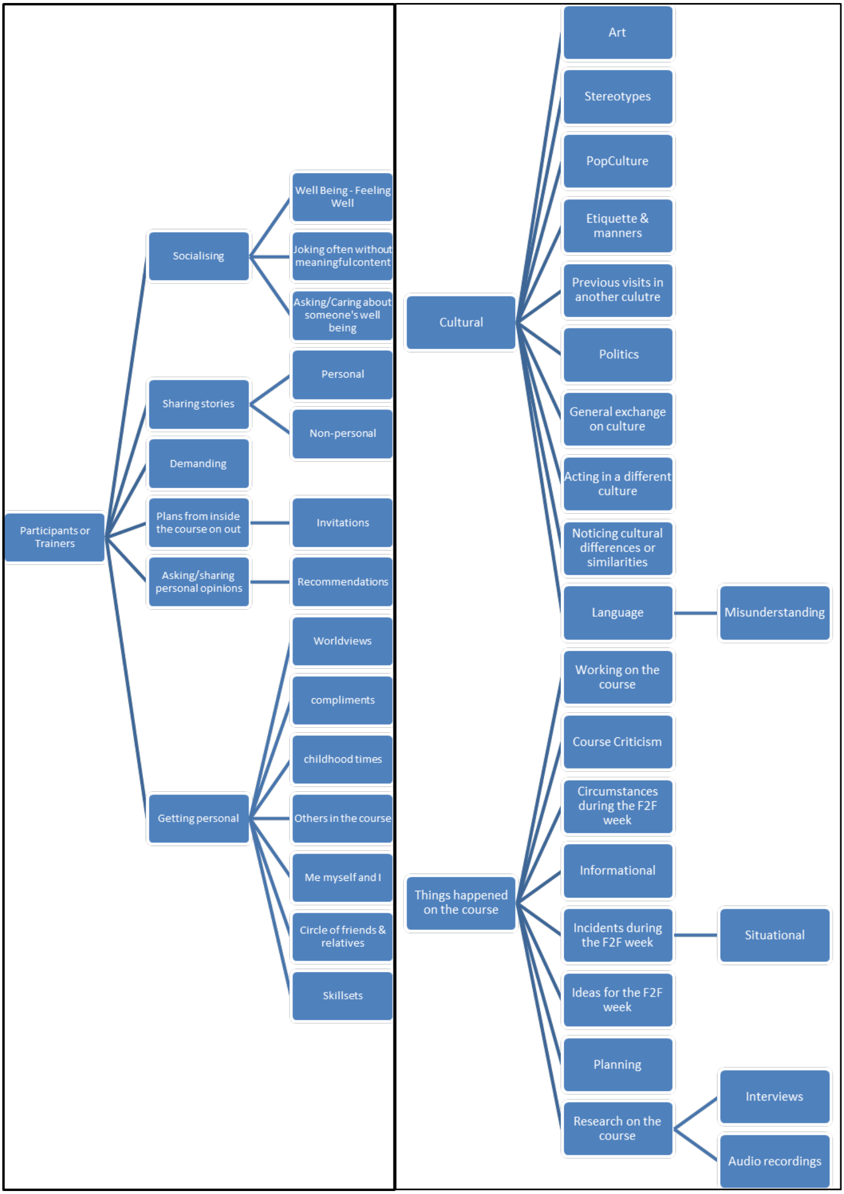


Figure 7.2 Structure of the code system – Part1

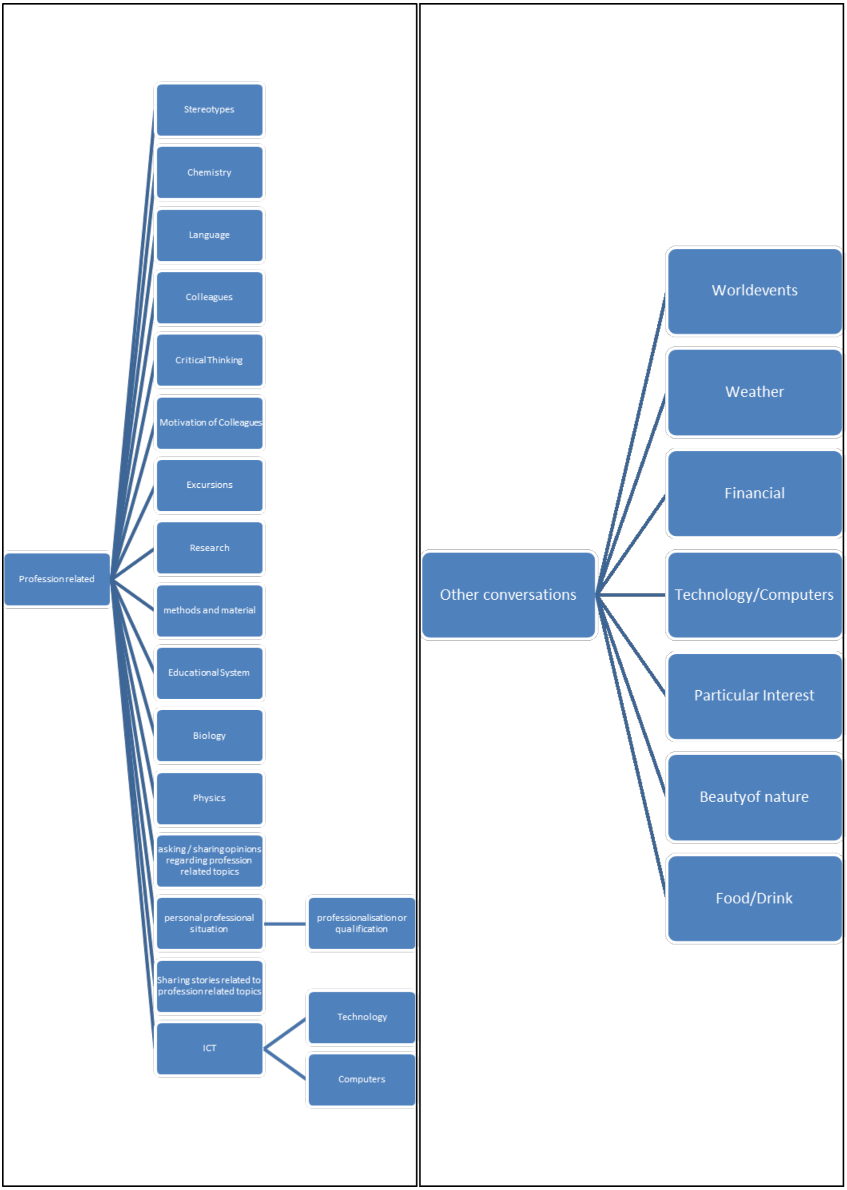


Figure 7.3 Structure of the code system – Part2

The individual codes are only coded on Level Two or Level Three. The aggregations (Level One) and the codings (Level Two and Level One) are based on the following code descriptions:

- **Participants or Trainers:**
  The main category contains all parts of a conversation that are dealing with a specific participant or trainer or a group of participants or trainers including social interactions that are targeted at or related to building individual relationships or adding to the cohesion of the group. The subcategories are:
  - **Socialising:**
    Socialising is a subcategory of "Participants or Trainers" that deals with aspects of people using different means to connect to each other. Socialising in our material came up in the form of several different aspects that became subsubcategories. These are the assigned subsubcategories:
    * Asking/caring about so. well-being:
      This code is applied, when people show genuine care or concern for someone's well-being either in the form of a question or in the form of serving someone or offering assistance. It only refers to direct interactions with the person that the care is directed towards.
    * Joking often without meaningful content:
      This code is applied, when participants or trainers say something humorously that is not bound to deliver any sensible, meaningful information other than the joke itself. It is also coded however when the joke carries some deeper meaning.
    * Well-being / feeling well:
      This code is applied when somebody is talking about (not) enjoying oneself at a particular moment inside the training course context and possible reasons for it. It does not necessarily refer to the speaker alone but can include exchanging information about the (not) well-being or enjoyment of third persons.
  - **Sharing stories:**
    The subcategory of sharing stories is applicable when stories are exchanged in the form of anecdotes. The anecdotes can be personal or fictitious and also in the form of deliberately exaggerated stories. The subsubcategories are:

    * personal:
      for stories that happened to the person telling it.
    * non-personal:
      for stories that are fictitious or about third-persons.

  – **Plans from inside the course on out:**
    This subcategory applies to conversations talking about plans by participants for the time after the teacher training course week. It includes private and professional plans for the future. This subcategory includes the subsubcategory:

    * Invitations:
      This category is coded, when conversations about plans include invitations by trainers or participants.

  – **Asking/sharing personal opinions:**
    This category is applicable when participants or trainers give or ask personal opinions or venture guesses. They may include implicit or explicit personal judgements on stories. When opinions or assumptions take the form of stories that are obviously exaggerated or invented, the category "sharing stories" is coded. This category excludes all opinions regarding professional matters. Profession related opinions or questions are coded with "asking / sharing opinions related to profession related topics". Also excluded are profound convictions that take the form of a worldview. The category contains the subsubcategory

    * Recommendations:
      The category is coded when people give personal endorsements.

  – **Getting Personal:**
    This category deals with conversations in which participants are trying to get to know more about each other. Unlike the category "Socialising" it is directed towards the exchange of personal information. It can also contain small remarks that hint at a personal aspect in someone's life. This category is only used, when the conversation doesn't fit any other more specific category. It can involve conversations about a third person (see subsubcategory "Others in the course"). This code is not to be used in the conversation dealing with the professional situation. The subsubcategories are:

    * Worldviews:
      This is to be used for the expression of worldviews that are deeper than a mere opinion and reveal something about the beliefs of a

person. Worldviews are seen as a part of identity rather than a simple opinion.

* Compliments:
  This category is used for direct or indirect compliments (could also go into Socialising).
* Childhood Times:
  When participants or trainers talk about their childhood or youth, this code is to be applied.
* Others in the course:
  This category applies to people talking about personal matters regarding a third person or a group of persons that are not necessarily present at the time of speaking. It does not include compliments.
* Me, myself and I:
  In this point people describe themselves. It includes people describing how they live (place, circumstances etc.). It is also coded, when the information is given alongside and is not the main focus of the conversation.
* Circle of friends & relatives:
  This code is applied when speakers talk about their friends and/or family and give information. His code can coincide with codes like sharing stories.
* Skillsets:
  This code is used in conversations where people talk about certain skillsets that they possess or used to possess.

- **Cultural:**
  This main category deals with cultural differences, knowledge and identities. Its subcategories are:

  – **Art:**
  This category deals with participants or trainers talking about art excluded are elements of pop culture.

  – **Stereotypes:**
  Stereotypes must be clearly identifiable as such. If the remarks are based on facts acquired by study or further reading this category does not apply. Stereotypes often but not always are also categorized as "sharing personal opinion".

- **Pop Culture:**
  This subcategory refers to participants or trainers talking about items of pop culture.
- **Etiquette and manners:**
  People talking about the cultural topic of manners and etiquette from a meta perspective. The category does not include practicing those manners.
- **Cultural Visions:**
  Sharing intercultural plans or visions on a grander scale also for humorous purposes.
- **Previous visits in another culture:**
  This subcategory deals with conversations about visits to other countries also in anecdotal forms.
- **Politics:**
  This category is dealing with conversations on politics and global developments. It also contains issues and greater topics of society.
- **General exchange on culture:**
  This category gives a description of how things are in a participant's or trainer's own culture. Includes general cultural habits (not in the sense of manners/etiquette). Often serves as a more general category if the other categories do not seem to fit.
- **Acting in a different culture:**
  Meta reflection on how people act in different cultures.
- **Noticing cultural differences or similarities:**
  This category is for conversations that describe differences between or compare cultures directly. It also includes differences in lifestyles or forms of living. The category explicitly needs explicit or implicit reference of the differences. Do not code if less than two cultures are involved.
- **Language:**
  Questions of translation and meta communication on language belong to this category. It also includes the actual speaking of foreign languages to each other for the purpose of demonstrating the language. It does not include the use of one's mother tongue among other native speakers.
  * Misunderstanding:
    Refers to misunderstandings in another language often in the form of anecdotes.

- **Things that happened on the course:**
  This main category contains mainly communication about things that take place inside the face-to-face week of the teacher training course. Some conversations also refer to the distant learning phases of the teacher training course. The category has the following subcategories:

  - **Working on the course:**
    In this subcategory participants talk about working on the teacher training course on a meta reflection base.
  - **Course Criticism:**
    In this subcategory participants talk about criticism on the course's concept or the course's progression.
  - **Circumstances during the face-to-face week:**
    When the participants talk about circumstances around the face-to-face week (e.g. the hotel, weather or needs that participants have regarding certain circumstantial infrastructure like ATMs or internet connections etc.) this subcategory is coded.
  - **Informational:**
    The informational subcategory is dedicated to participants or trainers giving others information on course related matters. Often the information deal with program or location-based information.
  - **Incidents during the face-to-face week:**
    Incidents that happened on the course. It also includes reports noteworthy incidents/actions that are happening right at the moment of the recording (e.g. a group member taking a photo etc.). The difference between this category and the "situational" category being: This category describes activities happening in the foreground while situational refers to descriptions of circumstances that are in the background.
  - **Ideas for the face-to-face week:**
    Refers to ideas that might have to do with the course itself but also with ideas for things that might have to do with informal meetings between group members inside the face-to-face meeting.
  - **Planning:**
    Refers to plannings inside the course in Patras for the time in Patras – not necessarily regarding the course programme only. Includes conversations on planning for the future or previous plannings for the course taking place just now. Inside sessions planning may also refer to planning by participants inside group work sessions. This

is separated from informational – which is giving information that might be vital for planning but is not treated as planning itself.

- **Research on course:**
  When the fact that the course is subject to educational research becomes a topic in conversations. The subsubcategories of the category are:
  * Interviews:
    When participants talk about the interviews that were conducted inside the research.
  * Audio recordings:
    When participants or trainers talked about the recordings or the recorders.

- **Profession related:**
  This main category is looking at conversations that have the teaching profession, science education or related topics as main content. It is split up in several subcategories.
  - **Language:**
    In this category participants or trainers are talking about the use of foreign languages in teaching science (e.g. in software or the use of English as lingua franca) but also are talking about the translation of science related vocabulary or technical terms.
  - **Colleagues:**
    This category is applied when teachers talk about colleagues at work.
  - **Critical Thinking:**
    In this category the participants or trainers are reflecting critically on the educational system or the direction teaching has moved to and what practical consequences they would like to see changed or what practical implications they are struggling with.
  - **Motivation of Colleagues / Pupils:**
    The participants talk about motivational factors connected to teaching. Includes incidents and experiences that were motivating for pupils or colleagues as well as meta reflections on motivation as such.
  - **Excursions:**
    Participants talk about school excursions with their own classes or they talk about excursions they heard about. Can also include planning of excursions or gathering ideas for excursions.

- **Chemistry:**
  This category is dedicated to conversations about chemistry be it as a subject or be it as science as a content.
- **Research:**
  Here the participants or trainers reflect and converse about research in general. It can include discussing own projects, scientific methods or ideas for science projects. It may also contain opinions on science.
- **Methods and material:**
  In this field the participating teachers or trainers talk about methods and material, they are using at school or university. This includes exchanging tips and hints as well as good resources. It often describes the implementation of certain ideas.
- **Educational System:**
  Here people are talking about the educational system. The conversation can occur from a more general level down to a level that is influencing the teacher's work on a daily basis. On a more general level it can also include historic or cultural perspectives that influenced the educational system.
- **Biology:**
  This category is dedicated to conversations about biology be it as a subject or be it as science as a content.
- **Physics:**
  This category is dedicated to conversations about physics be it as a subject or be it as science as a content.
- **Asking / sharing opinions regarding profession related topics:**
  This category is applicable when participants or trainers give or ask personal opinions or venture guesses regarding professional matters. They may include implicit or explicit personal judgements on profession related stories. When opinions or assumptions take the form of stories that are obviously exaggerated or invented the category "sharing stories related to profession related topics" is coded. This category excludes all opinions regarding personal matters. Personal opinions or questions are coded with "asking / sharing personal opinions."
- **Personal professional situation / professionalisation or qualification:**
  This subcategory deals with participants or trainers talking about their own professional career, about important aspects and/or experiences with their work and at their workplace. It also includes possible qualifications that they took in the past or plan to take in the future.

  - **Technology:**
    This category deals with participating teachers talking about the use of ICT in class. This can either happen on a theoretical level or through shared experiences. Can also include experiences by third persons.
  - **Computers:**
    This category deals with teachers and trainers talking about the use of computers at school. These conversations include reflections on a more theoretical level as much as sharing of stories from teaching practice. Can also include experiences by third persons.
  - **Sharing stories related to profession related topics:**
    This category is for all profession related stories that do not fall under more specific other categories.

- **Other Conversations:**
  This main category is for conversations that do not fit into any of the other categories. It is divided into several subcategories that ranked highest in terms of quantity.

  - **Weather:**
    This category is dealing with conversations that are dealing with meteorological conditions be it on the location of the training or elsewhere in the world.
  - **Financial:**
    Participants talking about financial aspects. This can be about paying a bill or talking about one's own financial situation.
  - **Technology / Computers:**
    This is concerned with conversations that are dealing with Technology / Electronics or Computers outside the professional realm.
  - **Particular Interest:**
    This is a category for participants talking about special interests.
  - **Beauty of Nature:**
    This category involves people talking about observations of nature or environments with a non-biological focus. The focus of these conversations in the majority is of an aesthetic nature.
  - **Food / Drink:**
    This category deals with conversations about food and drink.

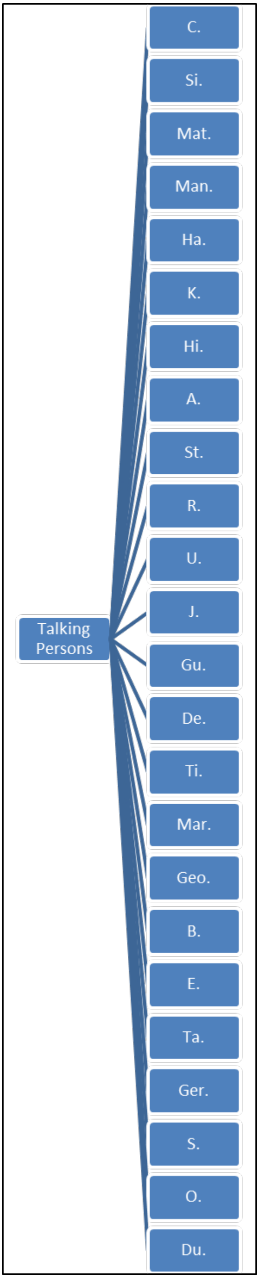


Figure 7.4 Structure of the code system – Part3

- **Situational:**
  As previously mentioned, the situational categories consist of three factors that were turned into document variables.

  – **Talking persons**
  This category codes the speakers inside of all recorded audio documents that were transcribed. All speakers were identified by listening to the recordings. All coders were trained in recognizing the speakers prior the transcription process (see subsection 7.1.1 on page 109). The code scheme can be seen in figure 7.4.

  – **Date & Time**
  This category marks the day of the recording – helping to analyse developments over the week. The subsubcategories are: Monday 28.3.2011; Tuesday 29.3.2011; Wednesday 30.3.2011, Thursday 31.3.2011, Friday 1.4.2011. The time of day is divided into four parts: morning, afternoon, evening and late evening. The time was originally intended to consist of four 6h intervals:

  Table 7.6 Deprecated 6h intervals for time of day

Morning	Afternoon	Evening	Late Evening
06:00–11:59	12:00–17:59	18:00–23:59	00:00–05:59

  As already written on page 113 this model was replaced by intervals of time that reflected the actual recording times. The begin of the late evening was determined by sleep onset according to Lack and Wright [2007, p. 1205] beginning at about 23:00.

  – **Situation & Location**
  The Situation and Location categories have been described on page 114 in table 7.3.

  Some conversations are partly incomprehensible due to challenging circumstances of recording these conversations. It is consequential that fragments of dialogues that do not show a clear attribution towards the items of the code system are collectively attributed to a code called “uncertain”.

7.1.5 Analysing topic related data

After describing the code system, we will now describe the method of quantification of conversations through the algorithm inside of MAXQDA 12. We will define each coded expression of a participant or trainer as **“speaker code(s)”**. The number of speaker codes is not determined by the length of a single expression but by how often individual speakers take turns. We shall exemplify this in a brief example:

Dialogue 1:

- A:“How are you, people?”
- B:“Fine...!”

Dialogue 2:

- A:“Can I ask you, how you felt today, and what would help you to feel better?”
- B:“Oh thank you for asking, this morning I felt a little bit grumpy – but then I was talking with some people and .. and it made me feel much better!”

In terms of length both dialogues are different. In terms of speaker codes they both would receive 2 counts if they had been coded in the same “if inside”-category: Inside the complex coding search of MAXQDA 12 the algorithm "if inside" checks the number of codes of certain types that were coded while a certain different code was active. By activating a specific topic code we can count the number of speaker codes that took place inside the activated code. In this manner we can determine how much speaker codes a certain topic triggered, and which topic stimulated the most reactions. We consciously decided not to factor in the length of contributions as we wanted to minimize the effect that different types of speakers or lengthy monologues had on the results. Speaker codes are unique, which means when a certain passage is coded with more than one code, the coded sections are counted separately for each code that was applied to the section. Based on the number of multiple codings this can lead to the number speaker codes being slightly higher than the actual number of people’s contributions. We decided for this way as it allowed us to present the data in ways that increase the readability.[10] When presenting results, we will thus not refer to the unit of characters, words or sentences, but refer to the unit of speaker codes the certain category produced.

[10]In this way all individual codes together add up to 100% and the relation between codes is easily understood.

7.1.6 Mode of analysing data

The results for research question one presented in the next chapter show correlations between certain contexts (situations and locations), times and topics that appeared inside the material. It is crucial to (repeatedly) point out the fact that correlation is not causation. Therefore, it is not sound to attribute any of these correlations to the factors currently under observation. This however is not the aim of the research at hand. In pursuit of research question 1b we are looking for the contexts that the conversations took place in in order to detect patterns that potentially might be of interest for further research. The analyses try to open a data and observation-based field for interesting hypotheses yet to be formed. In order to find candidates for interesting hypotheses, we need to look at our data very critically and try to discern important observations from random effects. This subsubsection will look into how the data can be sensibly reduced to that effect.

If we look at the development of numbers of speaker codes within certain Level-One or Level-Two categories over

- the course of the week
- certain times of the day
- within different locations or situations,

naturally the number of speaker codes will be very different – as the number of available recordings

- on every day
- on every time of day
- in every location or situation

turn out to be quite different. In terms of analysis this problem must be overcome in order to be able to detect valid conversational pattern changes in different contexts.

The obvious choice is to look at the distribution of speaker codes over one specific Level-One or Level-Two category in relation to all conversations recorded in the specific unit of analysis (e.g. a specific day; a specific time of day, a specific location or a specific situation). An appropriate way of doing so is by using percentages in relation to the measurement unit:

If for example the conversational patterns on Monday are to be compared with the conversational patterns on Tuesday, looking at the percentages of the distribution of speaker codes over the topics will give us a useful measure to directly compare the distribution of Monday's conversations with the distributions of the conversations on Tuesday.

However, looking at the percentages alone is not sufficient. Due to the different number of recordings (for example per day) the percentages themselves also may lead to a somewhat distorted picture, with any single percent possibly meaning a very different number of speaker codes connected to the individual field of topic. In this manner a slight distortion of a Level-One or Level-Two Code on a day with not so many recordings in general will lead to seemingly big changes in the distribution of topics – that have no real foundation in the data seemingly supporting it.

To circumvent this problem the reader has to have more information in order to be able to judge the quantity of the data at hand. Unfortunately, for the data at hand conventional statistical methods of determining significance had to be ruled out (for more details see page 136). So we had to come up with another method of determining the significance of the patterns detected. The mode of analysis was decided to incorporate three steps:

1. In a first step the complete dataset was presented in order to determine the baseline for the whole week of each Level-One, Level-Two or Level-Three category.

2. The second step depended on the analysis at hand – the unit of analysis permitting – in a second step the total number of speaker codes belonging to a specific Level-One or Level-Two category (as determined in the first step) is divided either by the number of days on record or by the number of times of day categorized[11] – in order to create a daily or day time related average speaker code ratio. This quality check serves to discern more representative data from less representative data. Only the data that meets or surpasses this average will be included in further analyses.

   The following figure 7.5 serves as an example explaining the procedure in closer detail:

[11] In our case four: Morning, Afternoon, Evening and Late Evening.

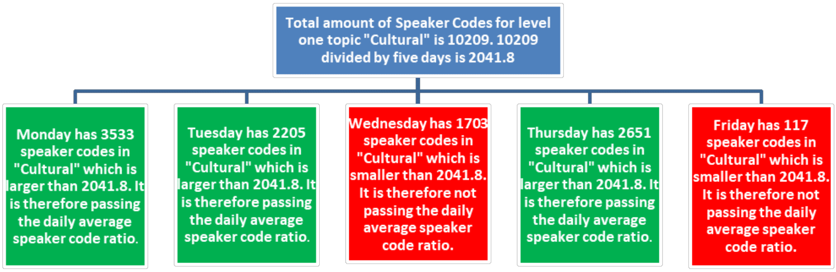


Figure 7.5 Schematic to explain the daily average speaker code ratio

This quality check was also implemented to judge whether any speaker had been represented appropriately with regards to a certain unit of analysis:

If person A for example had a lot of speaker codes on Monday and Tuesday, yet only had very little recorded speaker codes on Wednesday, then Wednesday was marked as not meeting the average speaker code ratio for said person. So the results could be judged more critically.

The location or situation-based analyses did not lend themselves to speaker code ratio related analyses and thus are not analysed in this manner.

3. In a third step an additional layer of information is presented to enable the reader to discern significant patterns of data from less significant patterns inside data. In this mode the confidence level with an alpha of 0.95 is calculated for each Level of the code system. This confidence level was added to the mean of the category: The idea being that deviations from the mean of the all Level-One and Level-Two codes respectively, which rise above the respective confidence intervals prove another way of discerning as the confidence interval will give the reader a measure of how certain (to a specified degree of certainty described by the alpha value picked) the true value will lie within the interval around any single value. In this way adding the mean and the confidence interval will give us a measure that reliably shows when an individual category value lies significantly above the mean.

The importance of this third step must not be underestimated, as some values that may have passed the test put up in the second step may turn out as not in a significant manner deviating from the mean in general.

In this work we will not look at significant deviations from the mean in the downward direction but only look at deviations from the mean in the upward direction: The simple reason being that we can obviously only account for conversations recorded – and not account for conversations that were not recorded. Other than significant deviations in the upward direction, significant deviations in the downward direction do not mean that the conversations did not take place within the unit of analysis – they simply may not have been recorded.

Conventional statistical methods

The reason for coming up with a different system for the detection of significant upward patterns in our analyses lies in the nature of our data: Other statistical methods like regression analyses (development of topics over the week or over the day in order to predict a development) and repeated measure designed analyses of variance (statistically checking the influence of different factors on the data) had to be ruled out due to the unusual structure of the dataset incorporating too many degrees of freedom and not fulfilling all conditions for parametric tests: Level-Two data proved to be not normally distributed in a Shapiro-Wilk test. This according to Field makes the data impossible to treat within parametric tests [Field et al., 2012, p. 654]. An alternative to parametric testing procedures according to Field can be found in non-parametric tests. Friedman's ANOVA is a testing method to reveal "differences between conditions when there are more than two conditions and the same participants have been used in all conditions (each case contributes several scores to the data)" [Field et al., 2012, p. 687]. Unfortunately, this ranked test (Friedman's ANOVA) typically fails to register the differences between the individual units of analysis due to the limitation that ranked tests in their very nature cannot register individual data spikes but only differences between the summed ranks of different conditions. This in our setting is not sufficient to detect significant changes between several different conditions.

7.2 Research question 2

Research question 2 reads as follows:

2. How precisely does the communication between the international participants of a blended-learning course for the use of ICT in science education evolve?

   (a) Which kind of patterns or phases regarding the informal communication can be detected?

   (b) How does the creation/development of a group structure look like in the light of a sociometric analysis? Are there signs inside the analysis that can be connected to a sustainable formation of groups beyond the lifetime of the project?

7.2.1 Speaker Codes and Turns

For the reader of this work it is necessary to understand the partly theoretical and partly pragmatic models that mark this work's vector of approach to the problem of finding suitable ways of a semi-automated analysis of teacher's informal conversations during the CAT teacher training. After the conversation's transcription and import into MAXQDA the texts were coded by several researchers and thus opened for the automated analysis of algorithms implemented in MAXQDA. As software is not yet capable of analysing conversations in a way that allows for autonomous classification of speakers and turns an apt approximation to the detection of conversations is required that would work using the algorithms implemented within MAXQDA 12. In the work at hand we started with a couple of reasonable yet also very simplified assumptions:

1. As determined by the transcription rules in subsection 7.1.1 most of the times sections or paragraphs in the transcripts mark whole conversations or at least sense units.

2. A conversation between two people is marked by one person answering another person. Meaning person B is answering or reacting to any statement another person A makes prior to the answer of B. Due to random sampling we could verify that in most conversations taking place in larger groups person A is much more often talking to the whole group and much less specifically addressing one individual person. So more often the remark by person A can be considered an open invitation to respond. Any person B's response in our simplified approximation is regarded as an individual B's choice to get in touch with A or rather connect to the remark person

A made and in a simplified sociometric view can be considered a vote of person A by person B.[12]

Using these two assumptions the amount of communication from one person to another can be approximated via the **"Followed by"** algorithm inside the **"Complex Coding Query"** in MAXQDA 12. The **"Followed by"** algorithm searches the specified material for segments assigned to any a group of specified codes (A) that are followed by segments assigned to specified coded (B) within no more than a specified number of paragraphs.

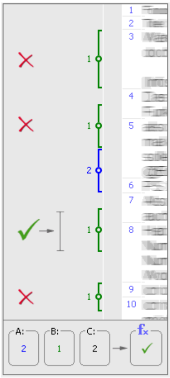


Figure 7.6 Example for the "Followed By" function of the "Complex Coding Query" in MAXQDA 12 – Screenshot

The official description inside the software describes the algorithm the following way:

"Search for segments assigned to any one of the codes listed in 'A' that is followed by a segment assigned to the code selected in 'B' within no more than X paragraphs. The number X is specified in 'C'."

When activating all the "Talking Person" codes and enter them in window 'A' and then one query after another subsequently enter every "Talking Person" category into window 'B' and setting the value for window 'C' to '0' and thus only counting inside the same section or paragraph (as previously explained in

[12] It is evident that this simplified model contains many inaccuracies and thus produces "false positives". It is important to understand that the analyses are based on a big data algorithm that produces valid results as long as the "false positives" are exceeded by "positives" inside a large dataset.

the rules of transcription on page 110: Paragraphs or sections in our transcripts are split into conversations or sense units), we receive a complete table of speaker turns directed from one person towards any other person recorded.

The algorithm counts all the instances of A appearing before B and repeats this action for another B appearing further down in the same section or paragraph. The algorithm thus produces a higher number for conversations that are bouncing back and forth between two people as these conversations trigger the algorithm to produce multiple counts. It also tends to produce higher counts for people that tend to talk a lot more. From here onward we will define the result from this algorithm between two persons the number of **"speaker turns"** between those persons.

The amount of real coded segments in the text for any individual person had already been defined as **"speaker codes"** in subsection 7.1.5. The algorithm counting **"speaker turns"** will lead to a slight distortion regarding the amount of the real conversational structure between two persons, as people who speak more, may end up with an unproportionally higher count of **"speaker turns"**. This however will not distort the relations between one person (Person A) towards another Person (Person B) compared to the relation that the same person (Person A) has to another person (Person C) as the speech patterns of a single person within certain limits tend to be rather stable. So that you can easily determine which persons are addressed by a certain person (Person A) primarily by comparing the number of **"speaker turns"** between persons.

As we are aiming for a sociographic representation of the conversational structure, we have to keep in mind that in **Force-Atlas** representations the attracting force of nodes that have many speaker codes per selected time interval is much greater than the attraction force of nodes that have less speaker codes per selected time interval. We will learn more on the algorithms which are used to calculate the position of the nodes and the way they are connected inside a larger attraction-repulsion model later (see subsection 7.2.4 on page 151).

It is important to note that transcriptions in the amount of conversations we are dealing with does contain errors either in the correct attribution of speakers or due to conversations spanning more than one paragraph because of the transcription of background conversations. However, the margin of error is small since the vast majority of speakers has been identified correctly and tests showed that conversations spanning more than one paragraph are simply regarded as new conversations but do not lead to a wrong interpretation regarding the overall speaker turns between two persons.

Before continuing with the methodology of research question two we need to take the reader to a brief introduction into two relevant fields, that are required to fully understand our methodology. We will address:

- sociometry in subsection 7.2.2 and
- network visualisation in subsection 7.2.3

7.2.2 Sociometry

Sociometry was developed by the psychotherapist Jacob L. Moreno in the early last century:

The word itself is a compound noun closely related to the Latin adjective socius,-a,-um meaning "common" or "connected" and being a participle adjective of the verb sequi (sequor, secutus) meaning "to follow" and also the noun socius, socii meaning "companion" or "associate" and the second word bearing close connections to the Latin word metrum that means "meter" (poetry) or "measure" (literature) – sociometry literally describes the measurement of *"associate-ness"* of small groups.

Moreno defined sociometry as *"the inquiry into the evolution and organization of groups and the position of individuals within them."* [Moreno, 1974, p. 29].

The localisation of the individual actor inside a network regarding his or her desired place within the network compared to the actual place inside the network for Moreno was the linchpin for the betterment of the group structure itself. According to Dollase, Moreno regarded the sociometry as indivisible from actual interventions that made use of the data gained from sociometric analyses to "heal" the system analysed in the sense of a sociatric improvement [cf. Dollase, 2013, p. 17].

Stadler describes sociometry as a mixed-method approach merging quantitative and qualitative approaches [see Stadler, 2013a, p. 9].

The fairly new aspect in Moreno's work was to grasp the social space as a holistic entity that in its great complexity required information and collaboration from inside the group (or network) to uncover its structures. Meaning the sociometric method is dependent on information from inside the network of individuals forming a specific group. The gathering of information from inside a network usually is the core element of a classic sociometric test: A classic example of the sociometric test is that the individual members of a group are asked to name the persons they would like to sit next to (sympathy) or to name the persons who they would not like to sit next to (antipathy). The classic sociometric test according to Dollase is not focused on just gathering information merely for the sake of collecting data – it rather has the purpose of aligning the structures of the context with the needs of the group as well as the individual that become apparent in the light of a sociometric analysis [see Dollase, 2013, p. 21]. In the example of the favourite person to sit next to you the sociometrist according to Moreno should adapt the seating arrangements to fit the sociometric preferences as best as possible.

Moreno's ideas also lead him to devising a strategy to depict social relations in graphic form: The sociograms, which became a predecessor of the modern ways to depict networks of (social) relations (see subsection 7.2.3 on page 147). The sociogram already contained many of the fundamental ideas of graphic representation of networks, which are used to this day unfortunately a closer examination of Moreno's ideas for sociograms would go beyond the scope of this work.

In Moreno's view sociometry could help to uncover the deep structure (e.g. the often hidden needs and wishes of the group members – the informal and interpersonal structures) and bring it in alignment with the surface structure (e.g. what merely appears to be the need of the group or of individuals). Rainer Dollase lists the following formal criteria for data gathered in a sociometric test:

1. **Relationality**
   Meaning the data in sociometric tests takes the form of "who-chose-whom" data.
2. **Double identification**
   The sender of wishes or opinions needs to be identified, anonymity is not possible neither with senders nor with receivers.
3. **Group specificity**
   The selection or rejection of opinions and perceptions are always connected to a specific collective.
4. **Freedom from limitations**
   Every member of the group can be sender or receiver of "who-chose-whom" data.

[Dollase, 2013, p. 16]

Sociometry thus provides a method of managing and supporting deep structures within the network.

The purpose of sociometry for teacher training designs

There is a validity to the question of what the actual purpose of gathering sociometric data of the CAT teacher training course might be with regards to the aims of this work. In what way can or could sociometric data be put to good use inside the design or the implementation of an international science teacher training course?
Dollase among others mentions the following benefits of the sociometric method:

1. It provides social sciences the ability to look at relations inside networks and groups and thus provides an insight into phenomena related to group dynamics.[13] [Dollase, 2013, p. 24]

2. Sociometry also allows for meta-reflections on or of groups that are leading to social learning processes – so a training group can on purpose be made aware of the fact that sociometric principles are also guiding their own interactions. [Dollase, 2013, pp. 25–26, Stadler, 2013c, p. 72]

3. Sociometric data can be used for purposes of optimizing the partitioning of groups. Dollase here especially highlights the necessity of not solely testing for sympathy but also to test for criteria that are *"handlungsrelevant"* meaning relevant for action. According to Dollase, empirical studies showed that by means of a sociometric group partitioning gains in productivity could be achieved. [Dollase, 2013, p. 26]

4. Dollase also mentions empirical studies that could show that peers usually are better suited to assess what a fellow group member is capable of doing [Dollase, 2013, p. 26]. And indeed, an investigation by Wherry and Fryer tried to find out whether sociometric "buddy ratings" were a beneficial leadership criterium or whether they were only sufficient to measure popularity of individual actors amongst a group. Their analysis included "a dozen of different criteria secured from several sources" [Wherry and Fryer, 1949, p. 179]. According to Wherry and Fryer, "even though a single rating may be unreliable, the average of a number of such ratings may provide a stable measure relatively free of bias and the idiosyncrasies of every single rater." [Wherry and Fryer, 1949, p. 180]. Wherry and Fryer found that while the combined sociometric peer evaluation of individual candidates came to conclusions within the first month – an assessment showing comparable results by superiors took roughly three months longer – furthermore:

[13] That is the way this work uses its sociometric data.

> *“While student nominations and student leadership ratings were about equal in stability after the passage of one months, both were more reliable than ratings assigned by either the Junior or Senior Tactical Officers.”.* [Wherry and Fryer, 1949, p. 185]

Wherry and Fryer also found that “buddy ratings” proved as reliable in making predictions about the retention or graduation of future officers as did the academic grades (see figure 7.7). Wherry and Fryer revealed another crucial aspect depicted in Table 4:

> *“Both criteria” they state “are equal in their relationship to separation and non-graduation. Thus it would appear that each is measuring an important aspect of success. Since the two criteria have low correlation, it is also clear that each is measuring a different aspect. In this situation, use of only one (and academic success is frequently used alone in such situations) would be doing only half the job.* ***Obviously ultimate success at Officer Candidate School depends as much on what buddy nominations measure as it does on what academic grades measure****”* [Wherry and Fryer, 1949, p. 187]

5. Dollase mentions the importance of validation of personal assessments of relations for several professional fields. According to him a comparison of results from a sociometric test with a sociomatrix filled out by the trainer could help to objectify the evaluations of the interrelations between members of the training group. With this regard Dollase also mentions empiric experience pointing to group leaders assessing only half of the relations between individuals correctly. Unfortunately, Dollase does not point to any concrete empiric research for this claim leaving it scientifically invalid. [Dollase, 2013, pp. 26–27]

At first glance a sociometric research on two officer candidate classes in 1949 might be judged as structurally too different from an international science teacher training and might eventually be rejected as an impermissible comparison of *“apples and oranges”*.

TABLE 4
CORRESPONDENCE OF CRITERION 1 (AN-S-S) AND CRITERION 10 (AAG-AI) TO RETENTION (FOR AT LEAST 2 MONTHS) AND TO GRADUATION

	Buddy Ratings (AN-S-S)	Academic Grades AAG-AI
Retention (at least 2 months)	.70	.71
Graduation	.49	.50

Figure 7.7 Table 4 from [Wherry and Fryer, 1949, p. 187]

Still so much as apples and oranges are both edible fruits we would like to consider a comparison of these two entirely different settings from a much broader perspective. Despite all the differences there are interesting commonalities at play:

In both settings a smaller group of instructors is training a larger group of trainees that in class and probably in more informal settings (like in a canteen or in a cafeteria) spent time with one another. In both settings it is very beneficial for the instructors to know about the individual strength and weaknesses regarding the field of training in order to be able to take individual measures of support or correction. Drawing leadership relevant information from the collective and in this way allowing the group to help increasing the efficiency of the training be it on an organisational level[14] or on a level of pointing out individual need for support structures could be a valuable complementary asset for any science teacher training, and further research in this matter is highly advised.

The age of computers, social networks and their impact on people's views on privacy

As social connections and the knowledge thereof are dominant and vital in so many different areas of our private and work life, the question remains why sociometry though widely used has not become the standard tool its professional value implicates. The real value of sociometry has been rediscovered by many of today's companies:

Using the information by single nodes to find out about the interrelations is the standard practice of social networks like Facebook and others. But many fields, though sociometry has had a deep impact in them, have not come to use sociometry as a standard tool.

Dollase suggests that this has to do with the lack of suitable and easy to use computer software when sociometry came up. A sociogram back then had to be crafted by hand and depending on the size of the group. This could turn out into

[14] According to Dollase, Van Zelst reports an increase in productivity of work groups by means of a sociometric partitioning of groups [Dollase, 2013, p. 26, Van Zelst, 1952].

a lot of work for the sociometrist. Another inhibiting factor described by Dollase was the protection of privacy [Dollase, 2013, p. 27]. Both factors are subject to fundamental societal changes:

There is easy to use software available that allows for the results of sociometric tests to be turned into meaningful sociograms in very little time with very little effort. Due to the comforts that tech companies promise their users by handing over private data, quite possibly today's society has also changed in their attitude with regard to the protection of privacy, allowing for sociometry to become a standard tool in science teacher trainings also.

A more objective sociometric testing procedure for special research purposes

The sociometric data gathered in this work in some respects differs from the data gathered by a classic sociometric test. This is due to the fact, that the sociometric test procedure in the way that Moreno originally had in mind is inept for research purposes that try to find out about the current state of the subject of research without too much interfering with it. Actually, the original purpose of a sociometric test the way Moreno had it in mind was an intervention in order to change the surface structure for the better – aligning it with the deep structure and thus foster social interactions.

For our research purposes an open sociometric test seems less appropriate as querying the subjects in a sociometric testing procedure itself might or might not have undesired effects on the relationships or conversation topics our research ultimately tries to measure. It is self-evident, that a question regarding the personal preferences of conversational partners would not only not go unnoticed by the participants but also quite possibly would cause an unwanted shift of conversation topics and/or conversation partners.

The research at hand is designed to interfere in the least possible way with the social processes self-directed by participants and trainers. This principle forbids us to refer to a classic sociometric test inside of our research. Stadler correctly points out the ethical dilemma:

For us to ask the question "Who do you want to sit next to?" without a following intervention and altering the seating arrangements according to the listed preferences by the course participants has the potential to cause "discontent that cannot be resolved". [Stadler, 2013c, p. 66]

Regarding the classic triad of quality criteria for research[15] Moreno's concept of a sociometric test comes with a set of advantages that increase their validity.[16]

[15] Objectivity, Validity, Reliability.

[16] The subjects are asked questions that they can give a clear and definitive answer to or deny an answer as such.

However they undoubtedly do have some issues regarding their objectivity: The sociometric test can never be entirely sure whether the information self-reported by the members of the network are accurate depictions or measurements of the deeper structure inside every network member. “The test is only as meaningful as the subjects are sufficiently self-reflexive and open and authentic in their statements” [Stadler, 2013c, p. 66]. This problem of decreased objectivity in parts can be tackled by asking relatively harmless questions, that still have the potential to seemingly reveal a person’s position inside the network. So Moreno’s classic example of asking every pupil inside a class whom they wanted to sit next to has to be regarded as having at least two sides to it: For one the question contains the mere information of who a person wants to sit next to – on another level however the answer could be interpreted as an indication of sympathy or antipathy.[17]

In pursuit of a more objective result we asked ourselves whether or not the network could be analysed regarding its deeper structure without relying on a classic sociometric test with the self-reporting of nodes (or persons). As we have seen, relying on self-reporting alone would leave us with a somewhat decreased objectivity.

The answer we came up with is yes and no: The query is dependent on information from the nodes, however depending on the sociometric focus this information can also be obtained by an in-depth analysis of a voluntary self-monitoring. In our case the subjects were asked to record their informal conversations and thus gave a plethora of information of who they addressed and how often they did it – the great advantage being that the subjects while being able to give somewhat false or manipulated readings inside of a single sociometric test (query) it being highly unlikely that the choice of who they address and talk to over the entire week could be subject to manipulation in the same way. By closely analysing the communication relations between the individuals we avoid possible measuring inaccuracies through distortions created through direct sociometric testing itself and also avoid ethical problems that come by sociometric testing without beneficial consequences for the group tested. We can say that the permanently renewed choice of conversational partners quite literally speaks for itself.

[17] It is not entirely clear whether Moreno would have approved of the second interpretation of his sociometric testing procedures, as for him the test first and foremost was intended to provide concrete information of how to rearrange the surface structure of any setting to more and more match the deeper structure. As we stated earlier in his example, it is very likely that Moreno would merely have rearranged the seats to as best match the results of his sociometric test.

7.2.3 Network Visualisation

Since the interdisciplinary works of Moreno [1974] and Granovetter [1973] many disciplines have discovered the importance of network systems and network analysis as such:

Cherven [cf. 2015, p. 9] reports that in biology networks have been analysed to show relationships between predators and prey or to show neural networks inside the brain; in the analysis of social networks or the flow of information on the internet the analysis of networks is a meaningful tool for gaining insight; also in the world of business networks play a very important role to describe the relationships between companies and depict financial dependencies. Tools to depict, describe and analyse networks are native in many disciplines and as Moreno's initial example for sociometric tests shows (see subsection 7.2.2 on page 140f.) can also be used by educational science to analyse and reveal internal structures inside classrooms and also inside teacher training courses. In this chapter we want to give the reader a brief general insight into the tools and techniques of network visualisation.

Networks graphs "are collections of nodes (often called vertices) that are connected by edges (sometimes called connections, links or ties) to form a graph. Nodes can be thought of as individual elements in a network that might represent persons, places, or objects that collectively define a network." [Cherven, 2015, p. 10]. Networks can be displayed using undirected graphs meaning every edge AB connecting the points A and B can be also interpreted as symmetrically connecting point B to point A or they can be displayed using directed graphs in which case an edge AB may connect point A to point B without the point B necessarily having any connection to point A. Directed graphs are usually depicted by arrows [Trappmann et al., 2011, p. 18]. In network analysis the graph is often analysed using different mathematical concepts. Important concepts are:

- **Paths**
  The connections between one node A and another node E can form a path. The path might cross several other network nodes (for instance B, C and D) before reaching its final destination.

- **Cycles**
  A cycle is a special version of a path with three or more edges and the first and the last node being exactly the same node.

- **Connectivity**
  Connectivity is a measure for the connectedness of a graph. It can be determined by a set of different algorithms. A common form are the alpha, beta and gamma **Indexes**.

  - The alpha index evaluates the number of cycles in a graph relative to the possible number of cycles. A perfectly connected network would have the score of one. And would also mark an (inefficient) network with high redundancies.
  - The beta index is calculated by dividing the number of edges by the number of nodes in a graph. Very simple networks tend to have a score of less than one, while more dense networks usually have a beta index greater than one.
  - The gamma index calculates the number of actual links divided by the number of possible links, which also returns a value between zero and one. The better the network is connected, the closer the index will turn to one.

- **Centrality**
  One of the most important concepts of network analysis is the idea of centrality: Centrality tries to understand the influence of a single node within the network. Trappman describes it as a means of "localizing the 'most important' actors inside of a network" [Trappmann et al., 2011, p. 27]. In network analysis there are four very different ways to determine the centrality (toward a certain function) within the network. **Closeness centrality** is a measure of the nearness of one node to all other nodes within the graph. A node with a high measure of closeness centrality tends to have shorter paths to all other nodes within the network. **Betweenness centrality** is a measure for nodes that are important in connecting otherwise remote or even disconnected regions of a graph. These nodes are likely to act as a bridge between different "regions" or clusters of the graph and thus play a key role in reducing path distances when traversing the graph. The **Eigenvector centrality** defines the connectedness of a node with neighbouring nodes that in terms of their connectedness are highly influential inside the network. Even though in terms of connectedness a node might not be so influential by itself its eigenvector centrality might still be high by being connected to highly influential neighbouring nodes. **Degree centrality** measures the number of nodes connected (be it through in-bound or out-bound connections) to a specific node. This measure not necessarily has to indicate that the node itself is a source of information (though it could be). In a network it certainly can serve as a hub for information to be dispersed through the network.

- **Degree prestige**
  Prestige is defined as the importance of a node regarding the in-degree votes.

According to Trappmann et al. prestige has a very simple measure concept – prestige can be measured as the relative in-degree of that actor. You can determine the relative in-degree by dividing the amount of in-degree elections by the number of actors in the network minus one. The relative in-degree is a standardized Index for prestige that is independent of group sizes – Trappmann et al. however mention the exception that capacity of contacts does not proportionally increase with group size [Trappmann et al., 2011, pp. 31–32]. Due to our methodological setup (see subsection 7.2.1) we face some impediments in determining the degree prestige in an accurate manner:

1. Due to the MAXQDA algorithm we chose to spot conversations, and by using speaker turns instead of speaker codes participants that converse more end up with unproportionally higher in-degree votes (see page 137). This will inevitably lead to higher prestige votes, that must not be interpreted in a linear fashion.
2. Due to using recording devices in order to determine what participant chose what other participant to talk to – a lot of "meaningful votes" (that is other, unrecorded conversations) that happened outside the coverage of the recording devices are not registered and might lead to distortions of the degree prestige also. We discussed this problem earlier (see page 135) and found a solution in determining a speaker code ratio per day for every participant. It seems to be an appropriate measure only to include participants that meet or exceed their relative speaker code ratio for that day in the calculation of a prestige degree.

- **Components**
  In more complex networks analysis of networks may need to differentiate between **connected** and **disconnected** networks. A connected network means that every node has a path to every other node in the network – this path does not need to be a direct path. In our case all networks were fully **connected**.

- **Homophily**
  "Homophily is the principle that a contact between similar people occurs at a higher rate than among dissimilar people" [McPherson et al., 2001]. This tendency in some cases is an inhibition for information travelling through a network as homophile clusters tend to keep information inside the cluster rather than passing it on to other clusters. Networks also are analysed as to why clusters inside a network have come to form in the first place. One possible explanation are commonalities in any salient characteristic

of any person inside the network (or different combinations thereof). Age, education level, gender, language, single or mutual sympathy are listed as common examples.

- **Clustering**
  Clustering is a measurement for the tendency of at least three nodes to be predominantly linked with each other. In network analysis clustering is detected by counting the number of completed triangles within a network. This method works, as it reliably rules out the counting of network parts that are only connected via one person these networks never are forming triangles, clustered nodes of more than three person however always can be divided into multiple triangles.

- **Diffusion**
  The way information moves through a network is described by the term diffusion. Diffusion is highly dependent on the attributes of a node: If a node is highly influential, the spread of information is expected to be faster. If a node is remote and not well connected, the information is more likely to spread more slowly and is less likely to reach every part of the network. Some nodes are important in connecting more remote parts of the network to the main cluster although themselves not necessarily being highly influential.

- **Layouts**
  A network graph can be displayed using different layouts to highlight various aspects of the network. A very common form of a layout is grounded on force-based algorithms, that pull connected nodes together while pushing nodes with no connections further apart. The links in force-based graphs can represent several aspects of a network analysis. It may mean general directed conversation in one graph or can refer only to professional conversations in another graph. One graph layout that is being used throughout this work is the "Force Atlas". The Force Atlas layout is described inside Gephi 0.9.2 in the following manner:

  "Force Atlas makes graphs more compact, readable, and can show authorities more central than hubs (Attraction Distrib. Option). Auto-stabilization improves convergence at the end of the layout."

  Force Atlas is a layout algorithm calculating a general repulsion between every node. This general repulsion is decreased by an attraction calculated between nodes that are connected to a great degree. All nodes are under a force pulling the nodes towards the centre of the graph, called gravity. The algorithm provides a high degree of accuracy.

Force Atlas contains various settings to model the graph according to several needs. Chevren describes the options the following way:

- *"Attraction: The attraction refers to the process of drawing nodes together based on their similarity or relatedness. Direct connections will draw nodes together, as will indirect connections through common neighbours.[. . .]"*
- *"Repulsion: This is a process that forces unrelated or distantly related nodes further apart from one another, which helps to space a graph and makes it easier to see relationships within the network.[. . .]"*
- *"Gravity: These settings allow users to define how nodes are drawn relative to the center of the graph. Lower gravity levels will disperse nodes toward the perimeter of the graph, with higher setting pulling points to the center.[. . .]."* [Cherven, 2015, pp. 70–71]

Gephi

Gephi is a software package written to visually display networks. It was first developed by students of the University of Technology of Compiègne in 2008 [Desmedt, 2011]. Meanwhile the ongoing development of Gephi is supported by a non-profit organisation called the Gephi Foundation. It was created for network visualisation and analysis. According to its website, it *"helps data analysts to intuitively reveal patterns and trends [...]"*. Gephi supports *"built-in functionality to explore, analyze, spatialize, filter, cluster, manipulate, export all types of networks."* [The Gephi Consortium, 2017]. The datasets were imported into Gephi using the *"import spreadsheet"* functionality.

7.2.4 Sociometric analyses using Force-Atlas representations of conversational networks

At first, we will take a closer look at the person to person communication of the whole week from a quasi-sociometric perspective using standard tools of network analysis. Using the software Gephi[18] we are able to find a graphic representation for the communicative interrelations between the participants.[19]

[18]See https://gephi.org/ In this work Version Gephi 0.9.2 201709241107 was used for analysis.

[19]In order to reproduce a comparable graphic representation, the raw data Excel Sheet (see Annex: 2) needs to be transposed and then imported as a Matrix (Intervals), then a "Force Atlas" Layout needs to be applied setting the repulsion to 50000, the attraction to 1.0 and activate the auto-stability feature setting the auto stability strength to 200.0. The group membership was determined by using the modularity feature with standard settings.

Gephi also allows for standard algorithms to be applied to the networks at and giving us key indicators to describe the network.

The Force Atlas – Algorithm

In pursuit of research question two, we can trace the evolution of our communication network by using the results of our analysis described in 7.2.1. Splitting the analysis into different stages (for example into days) we can trace the evolution of a sociometric network that is based on the objective data of analysed speaker turns. As already addressed in subsection 7.2.3 under *"Layouts"*, a Force Atlas graph applies a force model to each node that virtually repulses every node from every other node. Using the software Gephi we can visually represent the data generated using MAXQDA (see methodological description on page 137), we can then build a sociogram with each speaker being represented by a node and each interaction (in our case speaker turns are counted as interaction) between two nodes represented by an edge. Each present edge acts as an attracting force between those nodes: Nodes that generally interact more are drawing their partnering nodes closer towards them. This effect is multiplied if the conversations is mutual and with an equally active conversation partner. The size of the nodes is used to represent centralities (in this case: eigenvector centrality). The colour of the labelling represents the affiliation to a group of people that the modularity algorithm determines [see Blondel et al., 2008; Lambiotte et al., 2014].

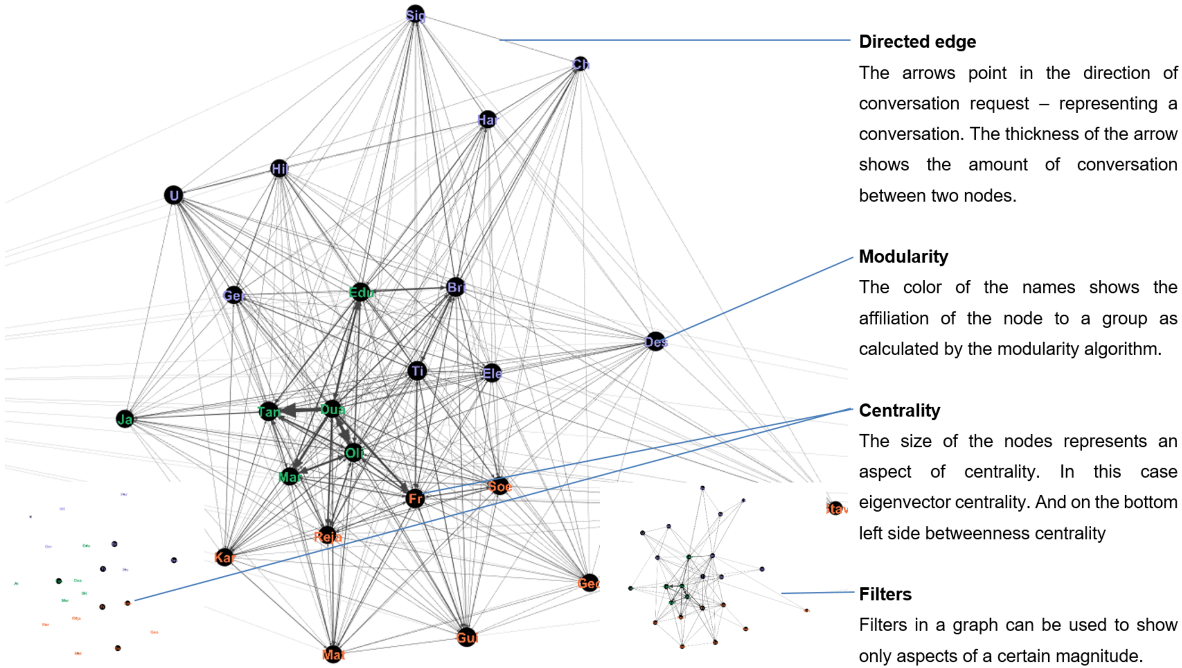


Figure 7.8 Legend for Gephi representation of the Communication using the “Force Atlas” Layout for the total communication over the whole week. Size of the nodes is eigenvector centrality effect and colour is modularity effect. Lower right side is a filtered view. Lower left side is a representation of betweenness centrality

For interpreting the graph, it is important to understand that it only represents conversations that were caught on the recording devices and further is slightly distorted due to the calculation of speaker turns (see page 137ff.) – so the graph has to be understood as an approximation to the real conversational networks. Especially for days with relatively few recordings (in this inquiry Wednesday and Friday) the network representation will very likely deviate from the real conversational structure on that day.

The enterprise of creating beneficial sociograms of every day of the training course is not without complications for another reason also: On some of the days individual participants or trainers simply might not have been on record at all or much less compared to their overall activity throughout the whole week. This in turn would immediately affect their position inside the sociogram of that day – and might very well have us draw faulty conclusions. Due to the methodology applied and limitations regarding the visibility range of all social interactions we cannot hope to resolve this issue to the full extent. However, we can solve it in a relative manner by attaching additional information to the top of every daily sociogram, allowing to put the daily activity regarding turns of every participant into relation with the full week record activity of speaker turns.

	Ch (m) GER	Sig (m) GER	Mat (m) FRA	Ger (m) GER	Har (m) AT	Oli (f) AT	Hila (f) FIN	Bri (f) GER	Edu (m) GER	Tan (f) POR	U (f) GER	Ele (f) GER/G	Dua (m) POR
Total Today	8	11	2256	1347	0	6416	231	240	59	2939	494	801	8156
Average per Day	301,6	304,8	700,8	788,2	536	2879	713,8	1907,2	1813	1448,4	436,2	762,4	4319,4

Gui (m) FRA	Ti (m) FIN	Fr (m) FRAN	Mar (f) POR	Kar (f) FRAN	Alex (f) GRE	Stav (f) GRE	Reja (f) FRA	Ja (f) BUL	Geo (m) GRE	Des (f) GRE	Soe (m) GER	Man (f) GER
780	428	4553	3067	2325	0	0	2887	415	1252	936	1847	16
554,6	1989,4	1904,6	1394,6	961,8	5,4	209	1202,2	571,6	530,2	383,8	1054	89,6

Figure 7.9 Example for a relative speaker code ratio per day

This is done by attaching a table that calculated an average daily speaker code ratio for each individual and comparing it with their actual activity on that day (also see page 135). On days, when individuals exceed their expected daily average the table shows by how far the expected daily average is exceeded and is marked green. On days when individuals fall below their expected daily activity the table is marked red and shows how much under their expected daily activity the individuals were recorded on tape. We will further agree that in the written text only the abbreviations of names (e.g. Ger, Har, Ele etc.) that exceed or meet their expected daily activity will be spelled using bold letters. All abbreviation of names that fall below their expected daily activity are using standard non-bold letters (e.g. Ger, Har, Ele etc.).

7.3 Research question 3

Research question 3 reads as follows:

3. What reasonable well-founded conclusions can be drawn from looking at the analysis of the informal conversations and considering the knowledge we have about PD in general and effective teacher training courses in particular also taking account of related fields.

    (a) What is the current knowledge regarding teacher professionalization in general and effective teacher training courses in particular and how might informal contexts be adequately implemented?

    (b) What results from neighbouring social sciences are of relevance to draw conclusions from?

    (c) Which factors seem relevant for the design of modern teacher training courses?

7.3.1 Literature study

In order to follow the research cycle pointed out in 7.1 on page 115 the literature study had to be carried out after the coding of the material such as not to interfere with the method of inductive qualitative content analysis, which requires the code system to be established without any previously formulated theoretical concepts [see Mayring, 2010, p. 83].

In dependence on our provoking question in chapter 1 we decided to focus on fields that would be likely to have direct impact on the design of teacher training courses and that would lead us to formulating hypotheses that we believe should be and could be addressed and/or reflected by actors involved with either the design of science teacher trainings or with research in said field. Obviously, the set of highly relevant scientific literature across so many scientific fields is still much too vast to reflect on everything. We focussed on research that addressed the following areas:

- Professional Development
- (Science) Teachers
- informal group

From the research touching the above-mentioned fields, many works influenced our thinking and a lot of the research also was addressed inside this work. For answering research question three however, we filtered the research and narrowed down on research that we found to carry many practical implications for science teacher trainings. The individual fields of research that we hypothesize to yield strong practical implications sprung from the scientific fields of:

- Educational research
- PD research
- Psychology
- Sociology
- Social psychology

The actual works we referred to can be seen in figure 7.10:

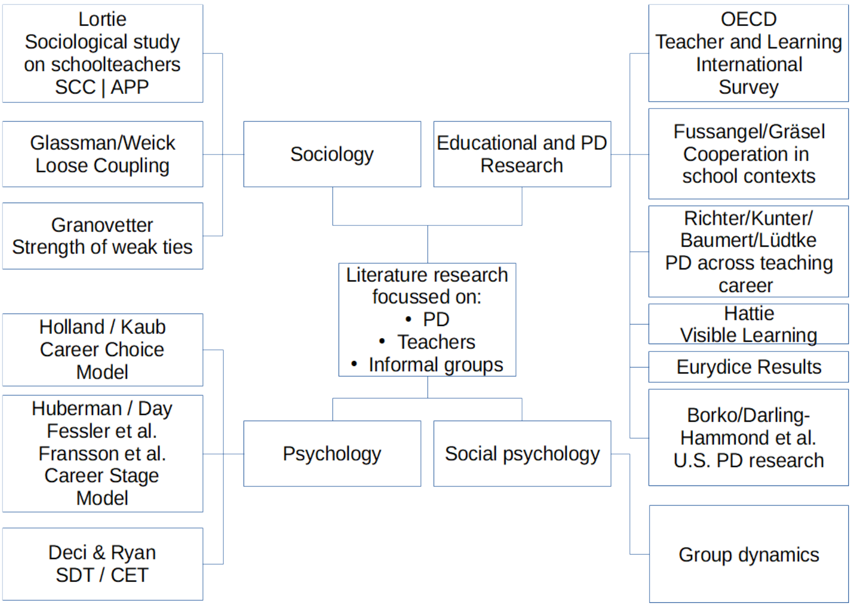


Figure 7.10 Literature focussed on to directly draw conclusions from for the design of science teacher training courses

The idea to draw on different angles and different levels of research has helped to draw a more comprehensive picture of the multiple contexts science teacher trainings are embedded in:

Sociology helped to understand the “customer” – namely the science teacher in relation to the system that he or she is working in:

By seeing some systemic mechanisms inside the institution “school” at play and thus getting the chance to possibly decode some of the subconscious structures that shape teacher’s behavioural patterns (e.g. SCC on pages 40f. or APP on pages 41f.) helps to adjust or emphasize some parts inside the design and implementation of teacher trainings that help to counterbalance, make use of or overcome behavioural patterns that either are beneficial or impedimental to PD. The idea of school as structurally defying change, that is introduced by Glassman and Weick (see Loose Coupling on pages 43ff.) also helps to reflect on ways and means to possibly increase the amount of shared variables between classroom and teacher training.

The sociological perspective also helped to understand and emphasize the structural importance of international science teacher trainings in particular (see the network perspective on pages 46ff.) – helping to orient the science teacher trainings towards the valuable aspects that participants might hold for each other and possibly also for the maintainers of the training course themselves.

Psychology similarly helped to understand possible dispositions of science teachers (see vocational personalities and work environments on pages 16ff.) that point to certain characteristics prevalent in science teachers, that can be reflected in determining adequate methods of training science teachers. Additionally, psychology gives us hints regarding the effects of the career stage teachers are in (see career stage models on pages 25ff.). It might allow for a quick and rough typology regarding a broader mindset of teachers within their professional career providing us with ideas of how to adequately address them. Motivational psychology (see CET on pages 100ff.) gives us an idea on how the general atmosphere of a training might be used to increase intrinsic motivation.

Educational and PD Research also thanks to research under the auspices of the OECD-TALIS provides a plethora of beneficial information that can inform course designers on a multitude of factors inside the field of science education. These information include age structure (see figure 3.1 on page 23), a decent idea of the weekly workload of science teachers (see figure 3.5 on page 34). TALIS also delivered insight into the barriers to participating in PD (see figure 4.1 on page 65) as well as the preferred forms of PD based on the rate of participation (see tables 4.2 on page 73 and 4.3 on page 74) and on the reported impact (see tables 4.4, 4.5 on pages 74f. and 4.6 on page 75). TALIS tried to find preferences regarding the general content of (science) teacher trainings (see table 4.7 on page

77), giving an idea on what content seems relevant to (science) teachers in the field.

Complementary to the TALIS data it was interesting to use Eurydice data to understand the current European wide educational policies that support or in some cases possibly constrict PD activities (see figures 4.1 on page 66, 4.2 on page 67 and 4.6 on page 80). Using data from TALIS 2013 we could see correlations between different forms of support and participation in PD and cumulative duration of PD (see figures 4.3 on page 68, 4.4 on page 69 and 4.5 on page 71) which help us to reflect on the design of the science teacher trainings based on the different political environments that international science teacher trainings might be operating in.

The research on teacher cooperation (see teacher cooperation on page 35) summarized by Fussangel and Gräsel [2014] is beneficial in assessing suitable forms for formal science teacher trainings extending into forms of teacher cooperation.

CHAPTER 8

RESULTS TO RESEARCH QUESTION 1: INFORMAL COMMUNICATION

In the beginning of this chapter we want to take the time to briefly repeat the methodological steps taken to analyse the informal communication inside the CAT course (also see subsection 7.1.5 on page 132 and subsection 7.1.6 on page 133):

In order to receive a more complete picture of the communication inside the training course the coded data needed to be analysed not only on the level of coded topics but rather down to the amount of **speaker codes**[1] that were coded while a certain topic was coded. The analysis of speaker codes within a certain topic code seems beneficial on multiple levels:

For one we are thus able to determine the amount of alternating speakers inside the actual conversation.

Secondly by carefully choosing specific sets of documents (or recordings)[2] and looking at the amount of speaker codes that occurred within of a specific topic code of that document, we can get a quantitative glimpse of the distribution of codes inside these carefully chosen documents.

As explained before we use MAXQDA's "Function" called *"If Inside"* that was designed to:

"Search for segments assigned to any of the codes listed in 'A' that are also completely surrounded by a segment assigned to the code selected in 'B' (MAXQDA 12 Menu)

[1]Speaker codes as opposed to speaker turns refers to the actual coding of different speakers inside the text. See page 137 for more.

[2]Based for example on date, time of day, location or situation.

inside MAXQDA's 12 Complex Coding Search. In this way we can select all speakers of interest in the Code Window A and the topic code of interest in Code Window B and thus end up with a specific number of Codes that were coded throughout a specific set of documents. In this chapter we will take a look at the results of this algorithm for the conversations according to different modes of analysis.

8.1 Results: Topics over time

As described thoroughly in subsection 7.1.4 on page 118 the topic codes are ordered on three levels of aggregation: Level-One represents the top level speaker codes for the entire week. Each of these Level-One codes is made up of several subcodes that are called Level-Two codes. Some of the Level-Two codes also have subcodes themselves that are called Level-Three codes. As already stated earlier, the codes were retrieved inductively from reflecting the transcriptions of the informal conversations by teachers and trainers. The distribution of Level-One codes turned out as follows (see figure 8.1):

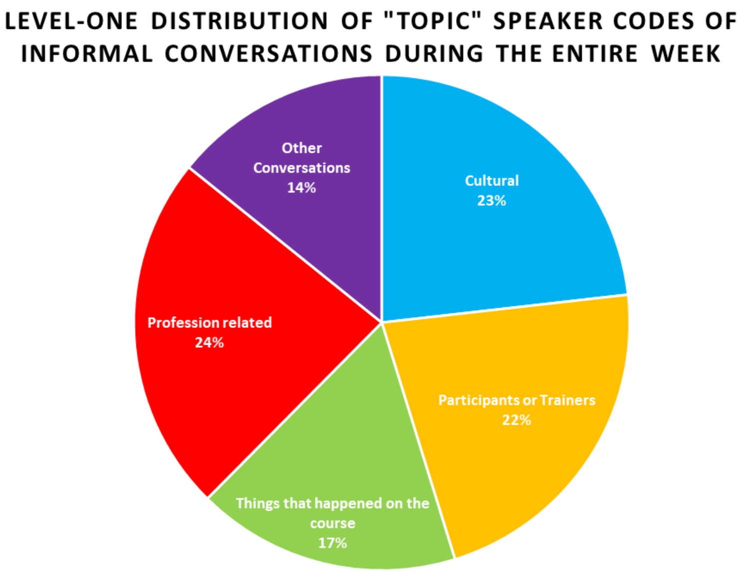


Figure 8.1 Level-One distribution of "topic" speaker codes of informal conversations during the entirety of the week.

It is remarkable that the percentage of the first level topic **"profession related"** conversations in informal contexts during the training amounts to 24% of the total amount of speaker codes. It means that participants and trainers seem to dedicate roughly around a quarter of their informal conversations to converse over professional matters. As stated earlier these categories are not generic categories applied *to* the data but instead are derived *from* the data itself. On Level-One they are however carefully distilled aggregations of all Level-Two and Level-Three codes of the entirety of informal conversations recorded (also see page 114).

The reflection on why the categories in figure 8.1 turned out to be the focus of conversations within the informal settings of the CAT science teacher training course in this chapter might prove to be a worthwhile endeavour, revealing some of the communicative preferences of science teachers. A closer look at the composition of the Level-One category **"profession related"** for example could provide insights on a supposedly little known form of informal learning between teachers that may run parallel to the official course curriculum. A closer look at the details of **"profession related"** conversations will be taken later (see figure 8.3).

Next to professional related conversations the other four areas are focused on **"cultural"** aspects, on **"participants and trainers"** and on the **"things that happened on the course"**. It is noticeable that all categories carry **situational aspects** inside:

- The profession related conversations are likely to be induced through the fact that the teacher training itself is concerned with the professional development of the individuals partaking in it. As we shall see later there are also indications pointing to individual sessions and programme points influencing the informal communication.

- As we see in the transcripts, the cultural conversations to a large extend are a result of teachers and trainers from different nationalities meeting each other in a foreign country and thus encountering a diverse and rich cultural environment.

- The strong aspect of conversations about participants and trainers can probably be explained by the fact that in this course most participants did not know each other before and are meeting for the first time.

- The conversations about "things that happened on the course" is the pinnacle of situational conversations as they are directly related to the experiences that happened during the face-to-face week of the teacher training course.

- “Other Conversations” are heavily influenced by situational factors (e.g. while in a restaurant a lot of conversations revolve around food)

Despite these assumptions regarding a stronger situational undercurrent being of a rather speculative nature as of yet, they may serve as a matrix of reflection for our following analysis of Level-Two codes. In the following we will show the distribution of Level-Two codes over the whole week. Identical colour codes are being used to show the associated First-Level codes (see figure 8.2):

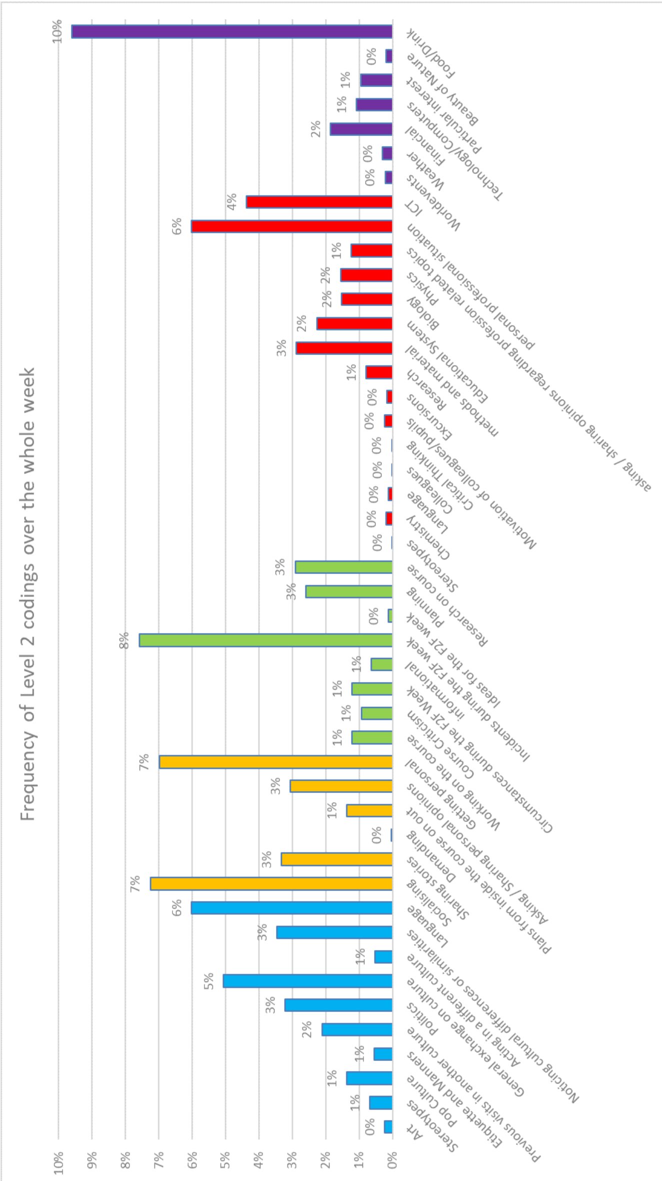


Figure 8.2 Level-Two distribution of speaker codes of informal conversations during the entirety of the week.

A look on the main Level-Two codings in a ranked format will help us to understand more of the general nature of informal conversations within the CAT course week. The majority of conversations over the week have been coded with the following Level-Two codes (see table 8.1):

Table 8.1 The 20 most coded Level-Two codes over the week

Rank	Code	%	Rank	Code	%
1.	Food/Drink	10 %	11.	Asking / Sharing personal opinions	3 %
2.	Incidents during the F2F week	8 %	12.	Research on course	3 %
3.	Socialising	7 %	13.	Methods and material	3 %
4.	Getting personal	7 %	14.	Planning	3 %
5.	Personal professional situation	6 %	15.	Educational System	2 %
6.	Language	6 %	16.	Previoud visits in another culture	2 %
7.	ICT	4 %	17.	Financial	2 %
8.	Noticing cultural differences or similarities	3 %	18.	Physics	2 %
9.	Sharing stories	3 %	19.	Biology	2 %
10.	Politics	3 %	20.	Pop Culture	1 %

These 20 Level-Two codes make up for 80% of the informal conversations over the whole week. In this chapter reasonable hypotheses are to be formed giving ideas as to why certain topics are addressed more frequently than others. These hypotheses are as such interpretations of the data at hand, that may lead to new ideas of looking at science teacher trainings in general.

As already suspected from looking at Level-One Codes, evaluating codes at Level-Two also indicates that situational aspects may have played a large role in informal conversations. The high percentage of **"Food/Drink"** may serve as a good example of how some settings and the typical actions that are associated with those settings seem to shape the conversations around it. In all restaurant locations the topic **"Food/Drink"** makes up for 17,38% of the total speaker code distribution.

All of the other major speaker codes distributions of the inductively gained categories also seem to contain a situational character:

The **"incidents during the F2F week"** may be interpreted for one as a need to reflect and communicate what is happening or has happened inside the group throughout the week but it also might point to the need of the group to form a collective group identity by reciting their **"common history"**.

The Level-Two code **“socialising”** forks into three Level-Three codes of which **“Joking often without meaningful content”** with close to 7% is by far the largest one (see Appendix B 1b). Inside this work it has to be pointed out that the humour found inside the conversations of this teacher training course has a strong tendency to contain situational aspects:

Looking at the humour inside the CAT course, humour seemed almost always to bear a close connection to the situation it occurred in (see Appendix B 1b and 3f). Due to humour being such a big part of all conversations it might prove to be a worthwhile endeavour for educational science to take a closer look at what kind of humour is dominant in the distinct phases of international science teacher training courses and what exact functions it serves from a group dynamic point of view. As will be discussed in the chapter about group dynamics it may be interesting to reflect on whether or not the humour in possibly quite a similar fashion as the reciting of **“incidents during the F2F week”** may serve as a tool of uniting the group and creating a common ground – while at the same time possibly finding one’s closer peers by finding a common sense of humour. Further research in this direction is advised as it might lead to complementary strategies to be used inside teacher trainings.

The Level-Two code **“Getting personal”** (7%) forks into seven Level-Three subcategories of which the subcategories **“Me, myself and I”** and **“Others in the course”** with together 4% of all the informal conversations mark another trajectory that might be suspected to point to another possible driving force of the informal conversations inside this science teacher training: Namely getting to know and getting in touch with each other – or in other words – to connect.

The urge to get to know the other (and to be known by the other) not only is quite likely to permeate the previous categories (next to their situational aspects) – it also can be found to permeate the “profession related” conversations: The strongest aspect of the profession related conversations and accounting for 6% of the total of informal conversations is the topic **“personal professional situation”**. As informal conversations around “profession related topics” are of particular interest in terms of informal learning opportunities inside format science teacher trainings, in the following passage we want to reflect on some hypotheses, of why the **personal professional situation** might have turned out to be the fifth most popular topic over the whole week inside informal conversations.

The strong prevalence of the Level-Two code "personal professional situation"

As already mentioned in subsection 3.6.1 (see page 49), we believe the relative strength of this value[3] to also be linked to Granovetter's ideas of *"weak ties"* [Granovetter, 1973, p. 1361]. The **personal professional situation** is of particular interest to the science teachers, as the **personal professional situation** in an international science teacher training often originate from a different educational system and thus are likely to describe similar problems in different ways. These new perspectives may often contain fresh ideas, that may stimulate the science teachers to reflect their own professional practice in different ways.

There is another hypothesis we would like to suggest with regards to the relative prevalence of the **personal professional situation** in informal conversations inside our science teacher training:

Inside our data we were able to perceive conversational pattern changes between "informal" and "formal" conversations – also with regards to the topic of **"personal professional situations"**. By being able to compare a small chunk of **formal conversations** that happened during formal work sessions inside the course with **informal conversations** that took place directly before and after those sessions a change of patterns inside the profession related conversations became visible as we will describe in detail in the situational analyses later (see figure 8.19 on page 191). This change of pattern could provide clues as to how *informal* **profession related** conversations might be structurally different from **profession related** conversations inside the *formal* science training course sessions.

We believe it to be a reasonable hypothesis that this might also point to an idea already discussed earlier: In item 3.4.2 (see page 38), we saw that the *practical* knowledge is bound to be shaped differently compared to *formalized* knowledge [cf. Bromme and Tillema, 1995, p. 262]. We deem it possible, that the **personal professional situation** is one of the ways that teachers might share practical knowledge among themselves and that the generally high prevalence of this code might even indicate that teachers in the informal realms are trying to convert a lesson learned into *more* practical knowledge – in a way *making sense of it* by exchanging on **personal professional situations** that bear resemblance and are compatible with the lesson content learned inside a session.
This hypothesis however obviously requires more *in-depth* analysis of the inherent patterns inside each conversation coded this way.

[3]With the exception of Thursday the code "personal professional situation" constantly lay above the significance mark of 2,84%: Monday – 5,39%; Tuesday – 11,09%; Wednesday – 3,08%; Thursday – 2,14%; Friday – 4,31%

We also would like to point out that this hypothesis would also find some support in the light of a group dynamic interpretation (see section 3.7 on page 50). By trying to reflect teacher training session content on the background of their own experience in practice, science teachers may either identify with the content of the training and thus integrate it into their identity or they may reject it and decide not to trust the content presented. Either way we believe that the informal conversations we titled **personal professional situations** deserve more attention in terms of further PD research, as the differences in conversational patterns between informal and formal situations may have implications for learning taking place inside science teacher training courses: In case that these informal conversations in and of themselves do present their own realm of learning and the personal professional situation took up the major amount of speaker codes within the informal profession related conversations – it may prove worthwhile to investigate the role that the sharing of personal professional situations may play with regards to informal learning.

8.1.1 Profession related conversations over the whole week

Having just discussed some hypotheses on some of the top five Level-Two codes over the week ending with hypotheses on the prevalence of the Level-Two code **"personal professional situation"** we want to dedicate some time looking at what other **profession related** topics participants and trainers addressed inside the informal realm (see figure 8.3). Looking at the speaker code distribution of all profession related conversations we can see that the **personal professional situation** outranks the **ICT** related conversations that in parts also deal with the topic of the teacher training itself and also again with the different cultures established within the different educational systems. The third raked **method and material** also is likely to refer to course content being continually discussed in the informal realms of the CAT course. Obviously, the different methods and materials used in a different culture also stimulate exchange according to Granovetter's theories [Granovetter, 1973].

The **Educational System** we suspect to be a characteristic of the international setting of the course. Since participants came from different cultures, it proved interesting and also potentially beneficial to understand more of the **Educational Systems** the other participants came from and thus to possibly learn something new. Like with the Level-Two Codes **personal professional situation, methods and material** and **Educational System** before this topic to also might be motivated by Granovetter's theory of *"The Strength of Weak Ties"* [Granovetter, 1973]. **Physics** and **Biology** mostly refers to teachers discussing disciplinary problems or topics with like-minded colleagues. The category **asking / sharing opinions**

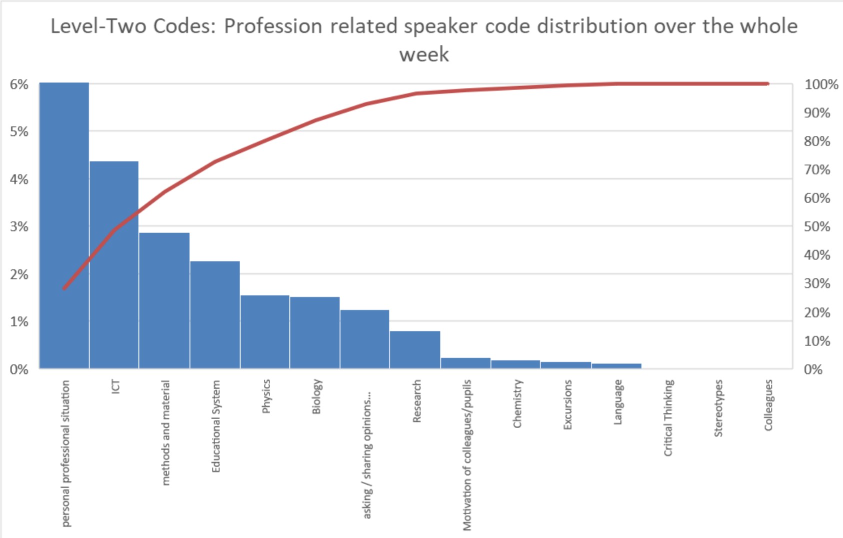


Figure 8.3 Level-Two codes: Profession related conversations over the whole F2F week. Percentage of total speaker code distribution

regarding profession related topics was relatively diverse with regards to the topics addressed. All other topics ranged below a one percent margin.

8.2 Analysing topic related data in different contexts

After having looked at the distribution of speaker codes over the whole week we will now take a more detailed look at the data regarding certain contexts. In subsection 8.2.1 we will start by looking at the data in the course of the week, trying to detect developments in the addressed topics over time. In subsection 8.2.2 we will look at topics addressed in informal conversations with regards to the time of day, also looking for possible patterns. Finally, in subsection 8.2.3 we will look at the possible influences that locations or situations may have had on informal conversations with regard to the topics addressed. It has to be stated that the location and situation based data in some cases included too few recordings for a reliable detection of patterns. In some cases location and times of day appeared to be entangled to certain degrees. The analyses under certain aspects however may prove beneficial in order to inspire hypotheses on what possible circumstantial influences may exist, that may or may not have an influence on the topics addressed by the participants and trainers.

8.2.1 The development of topics in the course of the week

Level-One Analysis

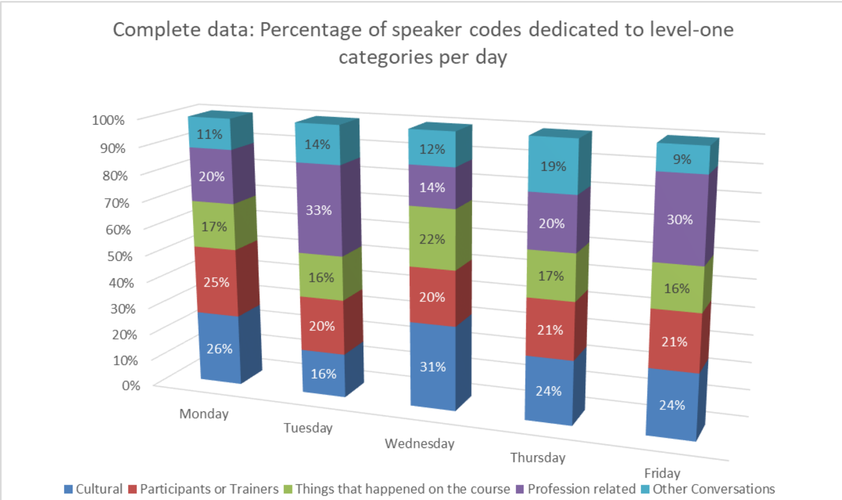


Figure 8.4 Complete data: Percentage of speaker codes dedicated to Level-One categories per day

In this section we will take a look at the complete Level-One dataset over the course of the week in order to detect the development of possible patterns. In figure 8.4 you can see the complete unfiltered dataset. It is noteworthy that over the course of the week the data for conversations about "Participants or Trainers" with the exception of a peak on Monday remains very stable. The same can be said for the aggregated data of the Level-One category "Things that happened on the course" it also shows to be rather stable over the week. The categories "profession related" and "cultural" seem to be inversely responding to each other on Tuesday and Wednesday, on Thursday and Friday it seems as if "profession related" inversely responded to "Other Conversations". However, these fluctuations are difficult to ascertain, as the recording time on Wednesdays and Fridays is significantly reduced. Those days fail to meet the daily average

speaker code ratio[4].
In the following table the coloured bars however fulfil or surpass the daily average speaker code ratio:

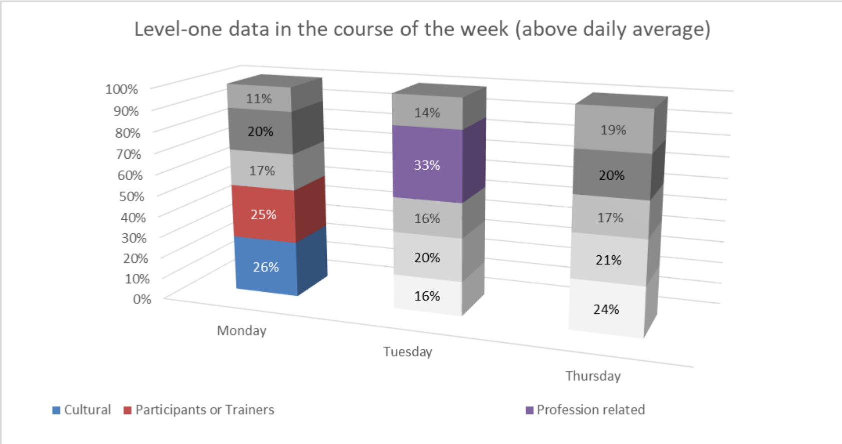


Figure 8.5 Level-One data in the course of the week only coloured bars meet or surpass the significant average speaker code ratio.

In Level-One categories the calculated mean value over the whole week is 20%, the confidence interval for Level-One data (95,0%) lies at 5,08%. Conclusively any deviation in Level-One data that is above the 25,08% mark can be treated as a significant upward deviation (see coloured bars in figure 8.5). From this data no clear trend[5] for the development of the First-Level categories is recognizable: It seems that on all three days that meet the daily average of speaker codes the conversation on **"Cultural"**, on **"Participants or Trainers"** and on "Profession related" are the most resorted to Level-One categories. However, only on day one and two are there significant upward deviations that are at the same time founded on sufficient recording data: On day one the main attention of the participants and trainers seems to be directed towards **"Cultural"** and **"Participants and trainers"**, which signifies the need of the participants and trainers to get acquainted with all other participants and trainers and either to grow accustomed to the cultural differences by conversing over them or using cultural differences

[4]See figure 7.5 on page 133.

[5]The reader should bear in mind that due to our methodology we can only mark trends that take place significantly upward of the mean, as the non-existence of a recorded conversation does not mean that according conversations did not take place. See step 3 on page 135.

as a conversational means to get to know each other. On day two the **"profession related"** conversations turn out to be unusually high: In the informal realm the primary school visit on Tuesday morning (see table 5.1 on page 97) kindled many profession related conversations. Other than that, no clear other patterns can be found inside the daily distribution of Level-One categories.

Level-Two Analysis

To complement the analysis of Level-One categories the development of Level-Two categories over the course of the week have to be taken into account and looked at thoroughly. By looking at the percentages that the speaker codes occupied of a topic compared to all speaker codes on record for that day – the distribution of topics over the day becomes visible in the chart of second-level categories. Due to the nature of the data gathering through optionally recorded audio files not every day received the same amount of data (a detailed listing of the amount of recordings can be found in table 2.1 on page 10) meaning the percentages cannot be taken as an indicator for quantitative shifts of topics throughout the week without further information. The data can however indicate shifts in the distribution of conversational patterns. After taking additional parameters of data quantity into account the development of a single topic can be traced by looking at the individual percentages produced on that day and portray its development over the week. Although in the second-level analysis days are not directly comparable with each other as different days have different amounts of recordings and thus a single percent may represent quite a different amount of speaker code.

As seen above on Wednesday and on Friday a lot less recording material was collected. This leads to almost all data of Wednesday and Friday to not pass the daily average speaker code ratio (see page 135f.). The Level-Two data has a calculated mean of 2,13% and a calculated confidence interval (95%) of 0,71%. This means that the data surmounting the 2,84% bar can be attributed to be a significant deviation from the mean. In figure 8.6 red marks were used in the graph to display multiples of the 2,84% significance mark.[6]

[6]The complete unfiltered data can be found in figure A.1 in Appendix A. Together these two graphs allow for a comprehensive view on the data regarding the development of every second-level category on record throughout every single day of the week (figure A.1) as well as allowing to detect significant deviations from the mean based on sufficient amounts of data (figure 8.6).

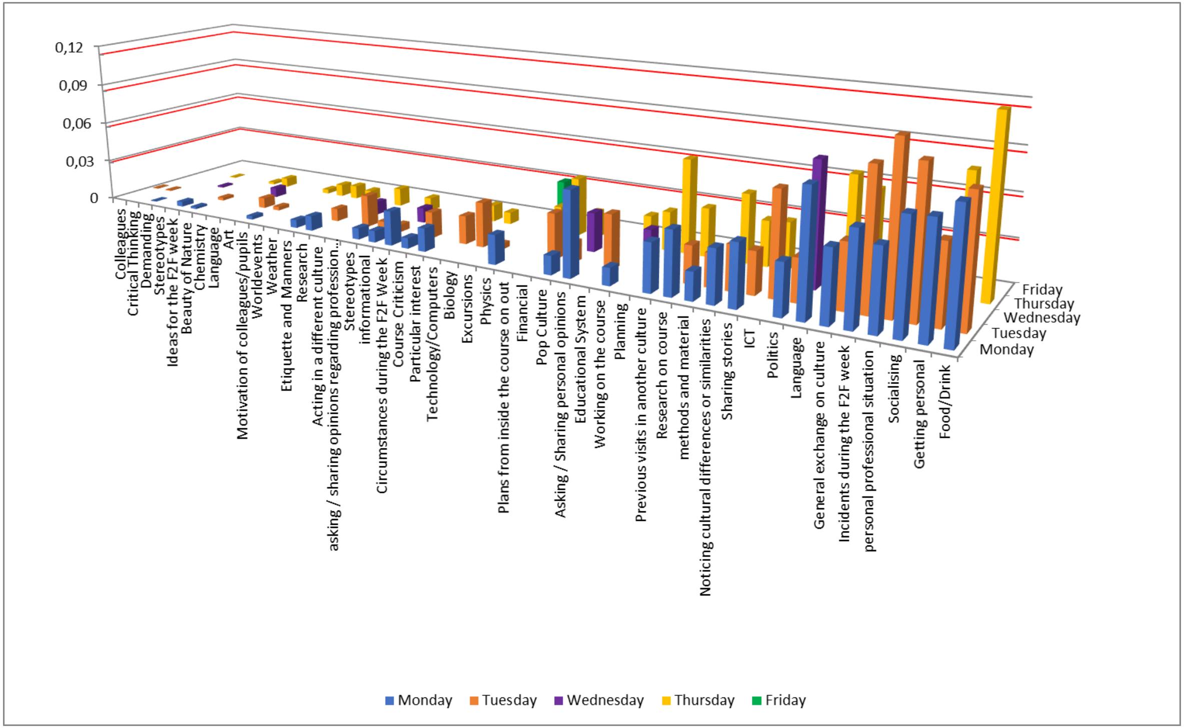


Figure 8.6 Development of topics over the course of the week fulfilling the daily average speaker code ratio. Data surpassing the red line are surpassing the 2,84% mark that indicates the mean plus the confidence interval (95%). All percentages can be found in Appendix B 1(b) i - *"Week Course"*.

Programme schedule influence informal conversations

On Monday we can see the Introduction and the Welcome Dinner influencing the percentage for **"Getting personal" – 7,46%** and **"Socialising" – 7,42%**, while the Walk to Achaia stimulated conversations about **"Language" – 8,33%** and also had an impact on **"Socialising" – 7,42%**. On Tuesday we see the primary school visit heavily reflected in an increase in conversations on **"personal professional situation" – 11,09%** and the Walking Tour through Patras impacting **"Socialising" – 9,81%**. On Thursday we can see the effects of the Farewell Dinner, which impacted **"Food/Drink" – 12,91%** and **"Getting personal" – 8,18%**. The prospect of departure the next day also influenced **"Plannings" – 6,59%** as some of the participants wanted to meet in Athens as well as **"Plans from inside the course on out" – 4,12%** as they were discussing of how to engage in further collaboration or personal visits (all percentages can be found in Appendix B 1(b) i - *"Week Course"*).

Despite these situational influences a clear pattern of development of certain topics throughout the week cannot be detected. It is noteworthy however, that although every day has a slightly different structure and not every topic is equally strong on each individual day, on the grand average topics that are strong on one day have a good chance of being strong also on other days.

8.2.2 Different times of day and their influence on topics

Since in our data we were unable to detect any specific clues regarding the development of conversational topics throughout the week; a possible correlation between the time of day and the participant's choice of topics remained to be checked. In order to do so, we divided the day into four different phases and looked at the distribution of the informal conversation topics among them.

Table 8.2 Number of speaker codes registered per time of day

	Morning	Afternoon	Evening	Late Evening
	08:00–12:00	12:01–17:59	18:00–22:59	23:00–01:30
Speaker codes	4112	15257	21059	3543

The apportionment of times of day had originally been planned to roughly span equal intervals of time of six hours each. Starting from six in the morning and possibly ending at 5:59 in the morning. This apportionment however did not match the dataset at hand: For one the participants and trainers obviously did not necessarily converse in the middle of the night – or if so, they did not record these conversations. Looking at the conversations themselves it was concluded that the nature of conversations was of a notably different nature already before midnight. It was thus decided to have the late evening shift start at 23:00 due to chronobiological reflections – sleep onset according to Lack and Wright [2007, p. 1205] begins at about 23:00. As no conversation was recorded past 1:30, the "late evening" label consequently was adapted to 23:00–01:30. Similarly as no conversation on record took place before 08:00 we also decided to label the morning more accurately as taking place between 08:00 and 12:00 instead of the originally intended 06:00–12:00 shift. However, despite the labels marking quite different intervals of time (4h in the morning; 6h in the afternoon, 5h in the evening, 2,5 hours in the late evening) – we will treat the intervals equally with regard to setting up an average speaker code ratio (see subsection 7.1.6) per time of day. Through this step, unusual deviations that are not backed by large amounts of speaker codes because of significantly less recordings taking place are facing a greater barrier to meet or surpass the average speaker code ratio, resulting in a higher assured validity of deviations.

In consequence, we will hereby define the use of a slightly different terminology valid for the Level-One and Level-Two analyses of the speaker code distributions over the times of day: In this analysis we will define "highly significant" values to meet or surpass the average speaker code ratio for a Level-One or Level-Two category[7] if the time of day consists of 5000 speaker codes or less and meets or surpasses the mean plus an added confidence interval (95%) for the Level-One or Level-Two category. As the data that is backed by a larger number of speaker codes[8] naturally meets or surpasses the average speaker code ratio more easily, we will define those values to be "significant"[9]. As the reader may have noticed, the methodological choice to use an equally partitioned "average speaker code ratio", despite the times of day not having equal amounts of recorded speaker codes leaves us with two cases that remain unsatisfactorily unresolved: We can mark "highly significant" times of day with 5000 speaker codes or less but we have no definition for "significant" times of day with 5000 speaker codes or less. Equally, we can mark "significant" times of day with more than 5000 speaker codes, but we have no definition in place for "highly significant" times of

[7] Total value of speaker codes within a category divided by four (representing the four times of day defined).

[8] Greater than 5000 speaker codes.

[9] The data that is backed by larger amounts of speaker codes could be viewed as being more representative with regards to the time of day the speaker codes were recorded in. We believe this indeed to be the case. However, due to the fact that more speaker codes also mean an increased chance of categories passing the barrier set by the average speaker code ratio, we define these values to be significant.

day with more than 5000 speaker codes. The decision to willingly accept these discontinuities in definitions is not arbitrary[10] but on purpose. The amount of data gathered within each time of day is unequally distributed – meaning the explanatory power of said data is different also:

While times of day with small numbers of speaker codes cannot hope to claim the same representativeness as times of day with much more speaker codes, they could point to individual categories, that are unusually high compared to a mean that exists over all times of day. It is reasonable to set the bar for those individual "peak" categories higher to compensate for the smaller number of speaker codes on record. Times of day with large amounts of speaker codes however can hope to be more representative over the distribution of conversational topics. In this regard it makes sense to put the bar of significance a little lower to be able to see more of how the distribution unfolds. The methodological choice at hand thus purposefully reflects and highlights the individual strength of the difference in the data itself.

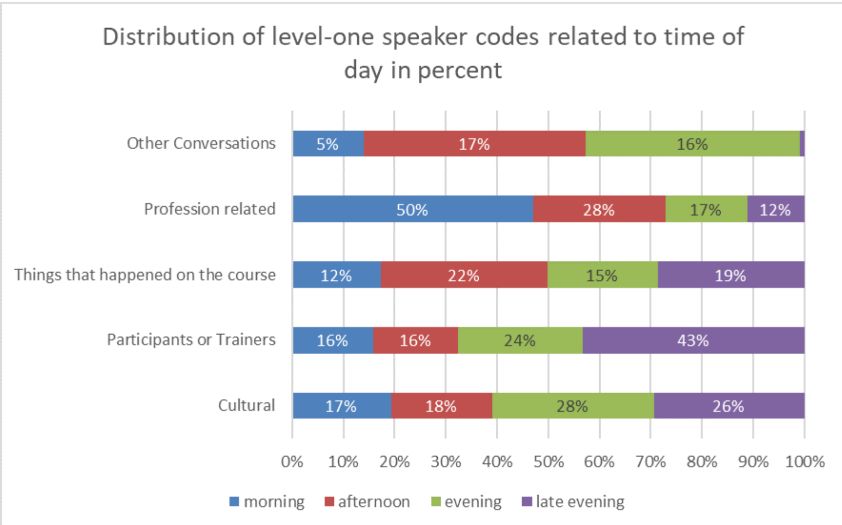


Figure 8.7 Distribution of Level-One speaker codes related to time of day in percent

Before looking at the distribution in terms of significance the data will be presented unfiltered. Looking at the distribution of the conversation topics with

[10] As it would be relatively simple to find suitable definitions for those discontinuities.

regard to the times of day they occurred in – some interesting patterns appeared. Figure 8.7 shows the unfiltered dataset.[11] Due to the methodology described in subsection 7.1.6 the dataset can be filtered to show the trends that can claim a higher validity: Two different methods have been applied to create the following figure 8.8: Only data that is greater than the mean plus the confidence interval (95%) is considered a significant deviation. For the Level-One data at hand this means only data surpassing the 25,08% mark is considered a significant or highly significant[12] upward deviation. The second method to assure an increased validity is through the consequent application of an average speaker code ratio as described in subsection 7.1.6: As mentioned before the data in the morning and in the late evening has a significantly lower number of speaker codes (see table 8.2) yet the average speaker code ratio was distributed equally over all four registered times of day – making it harder for the morning and late evening data to meet or surpass said average speaker code ratio.

As can be seen in figure 8.8 on the following page it is in part this strict limitation that accounts for the fact that a highly significant deviation cannot be accounted for in the morning and in the evening despite relatively high percentages.

Looking at the filtered data proves to be insightful: **"Profession related"** conversations happened to a great extend in the mornings (50%)[13] and then decreased over the day, while conversations regarding **"participants and trainers"** seemed to have happened to a large extend in the late evenings (43%) after having built up over the day. Both increased values however fail to pass the strict validity checks for "highly significant" values in place in our Level-One analysis – the profession related speaker codes only reach 80,3% of the average speaker code ratio and the participants and trainers only reach 62,24% of the average speaker code ratio.[14] It is worth however to keep an eye at the corresponding data within the following Level-Two analysis.

To be able to compare the level-two codes over the various times of day we have to look at the distribution of the topics inside of their time of day and then compare it with the relative frequency towards the other times of day. The following two

[11] Be aware that only the percentages inside a specific time of day refer to the same amount of speaker codes. This figure only shows different patterns emerging across the times of day – it does not contain statements about the quantity of conversations taking place inside a time of day.

[12] See above definition for "highly significant" and "significant values".

[13] With only some of the high concentration of profession related conversations in the mornings being due to large impact of the school visit on profession related conversations.

[14] This can be attributed either to the number of recordings acquired in the morning being too low or to the possibility that people might talk less in the mornings and late evenings in general.

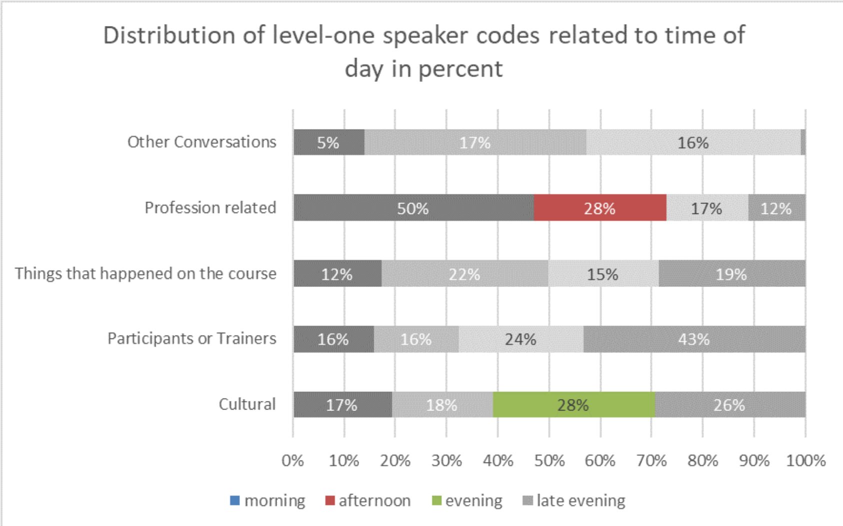


Figure 8.8 Filtered Level-One data distributed over times of day. Only coloured bars passed increased validity checks.

figures (8.9 and 8.10) give you an overview of what percentage of the speaker codes attributed to a certain time of day was occupied by a certain Level-Two code. In figure 8.9 all the data can be seen, in figure 8.10 only the data that met or surmounted the total number of codes in that area (e.g. “socialising”) divided by the four times of the day is displayed. Additionally, in figure 8.10 a red line indicates the mark of the mean plus a confidence interval (95%) which amounts to 3,08%. Bars surmounting the first red line or even multiple red lines in figure 8.10 are significant deviations from the norm with increased significance.

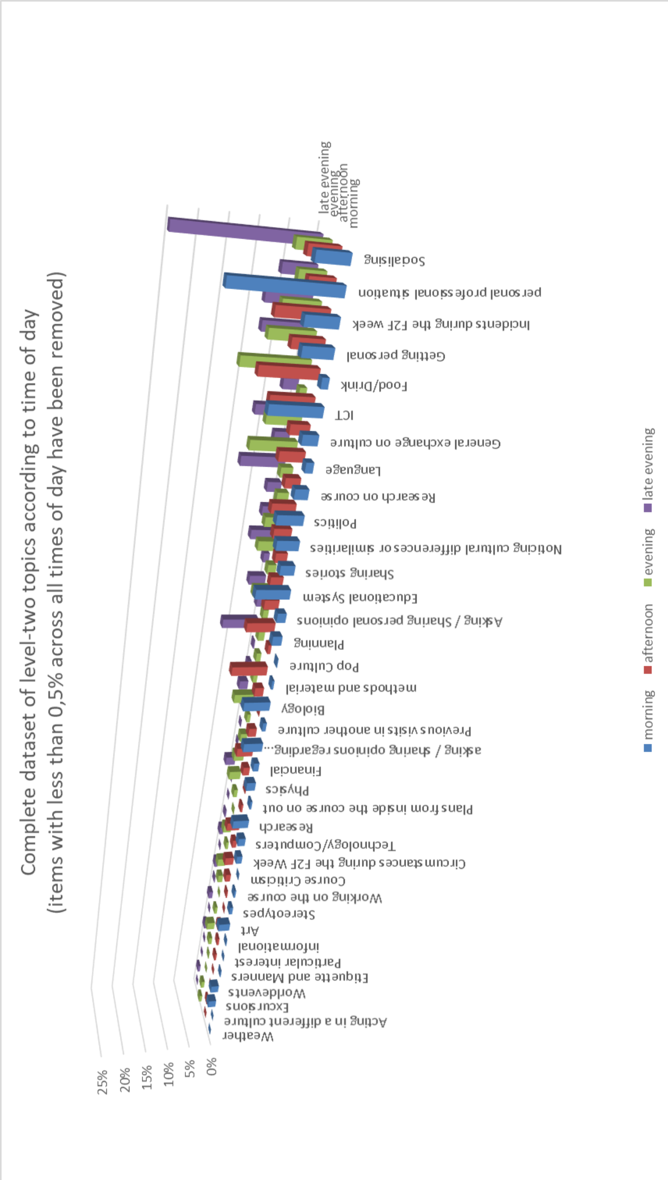


Figure 8.9 All relevant level-two topics according to the time of day. All percentages can be found in Appendix B 1(b) i - *"Whole Daytime"*.

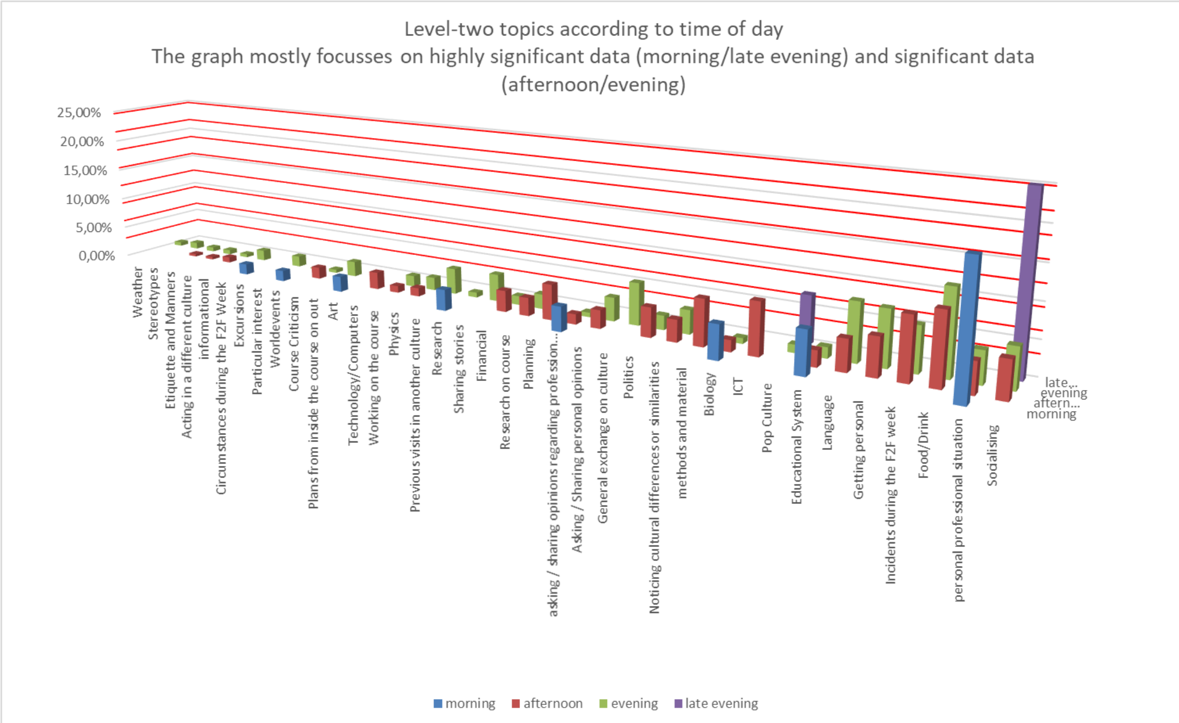


Figure 8.10 Relevant and significant level-two data of topics according to the time of day. Data surpassing the red line are surpassing the 3,08% mark that indicates the mean plus the confidence interval (95%). All percentages can be found in Appendix B 1(b) i - *"Whole Daytime"*.

As can be seen, there are some (highly) significant findings inside the Level-Two data.

The morning:

The morning is supported by 4112 speaker codes gathered in a time interval of four hours (08:00–12:00). It turns out that the number of "profession related" conversations that failed to meet the validity checks on Level-One are composed of a few individual Level-Two codes that do pass the validity checks in place for Level-Two codes.

The top conversational topic making up 19% (768 speaker codes) of the informal conversations in the morning are marked by "personal professional situation". As can be seen in the data, this percentage falls over the course of the day to 5% in the afternoon (537 speaker codes) and evening (749 speaker codes). This marks an important trend inside the data gathered. Interestingly all other highly significant Level-Two categories also belong to the Level-One category "profession related" together making up a combined 37%[15] of all informal conversations in the morning.

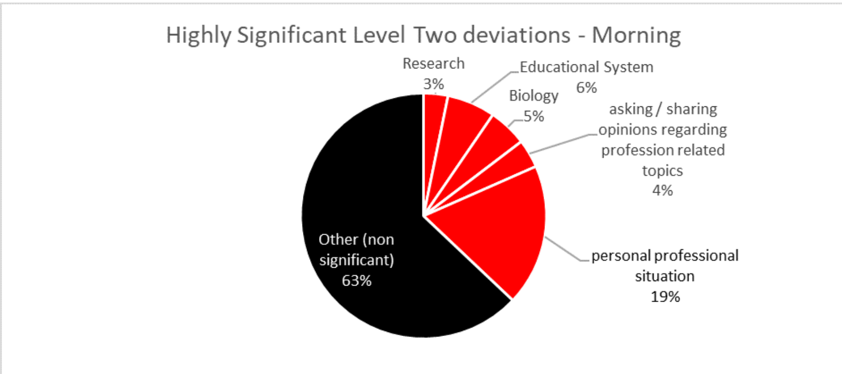


Figure 8.11 Highly Significant Level Two Deviations in the morning

Level-Two analysis clearly shows that in our course the primary school visit heavily impacted the conversations. Yet the trend was visible over the whole week, demonstrating that in our course morning was the time for conversations about the "personal professional situation" as well as sharing the peculiarities

[15]This number is lower than the 50% marked "profession related" in the Level-One analysis as some of the Level-Two categories did not pass the validity checks in place.

of the different “Educational Systems”, which obviously also was driven up due to the primary school visit. Teachers also seemed willing to submit to “asking / sharing opinions regarding profession related topics”. The significantly increased conversation about “Biology” was due to the fact that the recordings gathered took place between biology teachers. Obviously, the data of one teacher training course by no means can be considered representative. Other than the school visit there are no direct leads pointing to a cause for the unusually high preference for “personal professional situation” in the morning. The schedule however contains indications that may account for the composition of the Level-Two categories. Looking at the schedule (see page 97) we find that in the morning the following work sessions took place:

Table 8.3 Excerpt of the Schedule – Morning

Time of day	Monday	Tuesday	Wednesday	Thursday	Friday
Morning	Introduction into Module 2	Visit of a Primary School	Best practice examples	How to organize the classroom (3)	How to organize the classroom (4)

Four of these five sessions had a mid-high to high relation to the participant’s own professional practice. On Tuesday the teachers could directly compare the lessons held at the primary school to their own practice. On Wednesday the teachers were introduced to best practice examples and within the session and also were asked to introduce the other participants to best practice examples used within their own schools. On Thursday and Friday participants and trainers discussed implementation strategies in groups and introduced each other to the ideas discussed. Viewed from this background the large percentage of informal conversation regarding the **“personal professional situation”** could be directly influenced by the sessions around it.

Apart from the high significance in this international science teacher training course there is no indication, whether this pattern is reproducible in other contexts. Still, the strong emphasis on informally talking about the **“personal professional situation”** in the morning, surpassing the mean plus an added confidence interval by more than six times, seems to justify further investigations into the matter using similar data from comparable training courses.

The afternoon

The afternoon is backed by 15257 speaker codes and comprises a time interval of approximately five hours (12:01–17:59). With 28% in the Level-One category "profession related" the value is significantly above the average speaker code ratio for this category and also outreaches the Level-One category mean plus the added confidence interval (95%) for Level-One categories.

It is therefore only one of two values that manages to be highly significant also in the aggregated Level-One analysis. Unlike the speaker codes in the morning the Level-Two analysis for significant values shows significant values for different Level-Two categories. This also is due to the fact, that the bars for significant values in the afternoon or the evening are lower than the bars for highly significant values in the morning or late evening.

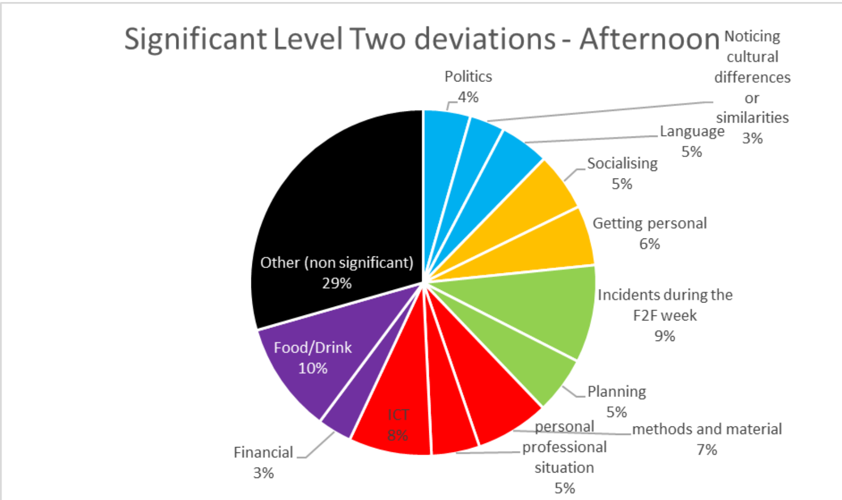


Figure 8.12 Significant Level-Two Deviations in the afternoon

Interpreting the Level-Two data for the afternoon is a non-trivial task. The appearance of several different Level-One categories opens a plethora of explanations as to why those categories might have played a significant role in informal conversations in the afternoon. Without further investigation this work can give no scientifically authoritative explanation. One of the aims of this work however is to carefully form hypotheses guided by the data at hand to inspire further research and discussion in this matter.

A careful interpretation

Looking at the chart (see figure 8.12) again we find situational factors reflected in the informal conversation bearing relations to the schedule (see table 8.4). The large lunch break for example is reflected in the 10% increase of the category **"Food"** plus small conversations recorded around the category **"Financial"** that deals with borrowing money, paying for the meals etc.
The session content "The future and its impact in the use of ICT in education" that dominates the afternoon on Monday and Tuesday is also reflected in the increase of **"ICT"** related conversations in the informal domain. The increased conversations about **"methods and material"** can be attributed to afternoon sessions of Wednesday and Thursday, when the teachers had to discuss previously learned methods in terms of didactics. The increase of **"Socialising"** and **"Getting personal"** can be attributed to the lunches as well as the breaks between the sessions. The cultural conversations also largely could be traced to the way to lunch, and to lunch itself.

Table 8.4 Excerpt of the Schedule – Afternoon

Time of day	Monday	Tuesday	Wednesday	Thursday	Friday
			Afternoon		
12-14	Lunch	Lunch	Lunch	Lunch	Lunch
14-16	The future and its impact in the use of ICT in education	The future and its impact in the use of ICT in education	How to organize the classroom (1+2) Intro + Groupwork	How to organize the classroom (4) Intro + Groupwork	Online phase preparation
16-18	The future and its impact in the use of ICT in education	The future and its impact in the use of ICT in education	How to organize the classroom (1+2) Presentation and discussion of GW	How to organize the classroom (4) Presentation and discussion of GW	Evaluation/ Feedback

The evening

In the evenings 21059 speaker codes were recorded. Across an interval of five hours (18:00–23:00). The significant Level-Two codes were distributed in the following way:

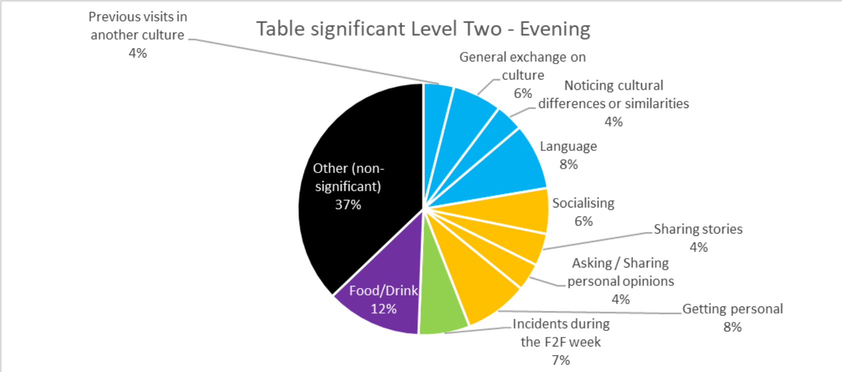


Figure 8.13 Significant Level Two Deviations in the evening

In the evening the cultural aspects are in the foreground. The cultural aspects are not only significant in terms of the Level-Two analysis with 28%, they also manage to mark a significant upward deviation from the average in the aggregated Level-One analysis.
The Level-Two analysis of speaker codes reveals an interesting conversational shift away from the profession related subcategories more to the personal and cultural aspects.

Table 8.5 Excerpt of the Schedule – Evening

Time of day	Monday	Tuesday	Wednesday	Thursday	Friday
			Evening		
18-20	Welcome dinner Achaia Beach	Walking Tour at Patras with part of the participants	Tour to Nafpaktos and dinner there with part of the participants	Farewell dinner Camping Rion	Journey home

The increase of “cultural” aspects possibly can be explained through situational factors again: As the program shows on Tuesday and Wednesday the evening was reserved for cultural activities. On Tuesdays an optional walking tour through the

Greek city of Patras[16] provided different cultural inputs that may have acted as a stimulus for conversation. On Wednesday the city of Nafpaktos[17] was visited and possibly also inspired some conversations in the evening. As can be seen communication about the languages made up 8% of the evening conversation. This in part may also be due to situational factors: The menu in the restaurants are filled with characters of the Greek alphabet as well as the tours through the city are filled Greek signs. Another possible explanation for talking about the language lies in the internationality of the participants and trainers. The cultural diversity of the group as such quite likely inspires conversations about the cultural differences.

The late evening

The recordings done in the late evening are based on 3543 codes that were recorded between 23:00 and 01:30. Interestingly all those recordings happened in the hotel bar and all recordings that took place in the bar happened in the late evening. The late evening includes the Level-Two codes you can see in figure 8.14 on the following page. Looking into the Level-Two code Socialising we find that 24% out of the 25% can be attributed to the Level-Three Code: "Joking often without meaningful content". It seems to be that the late evening is a domain that if at all serves a number of social functions that may be of relevance for the unity of the group.

[16] The city of Patras is Greek's third largest city. The city is described as a commercial hub, with a busy port. The teacher training itself took place at the University of Patras. At the time of the training the financial debt crisis that hit Greece in 2009 was in full swing and in some areas of Patras signs of the crisis being in effect were visible. Looking at the data we can see that the crisis did inspire some conversations.

[17] The city of Nafpaktos historically had a crucial gateway function regarding the Gulf of Corinth. Through changing hands it shows cultural aspects from the Ottoman Empire as well as it shows Venetian influences. The cultural diversity quite likely provides additional potential for cultural discussions.

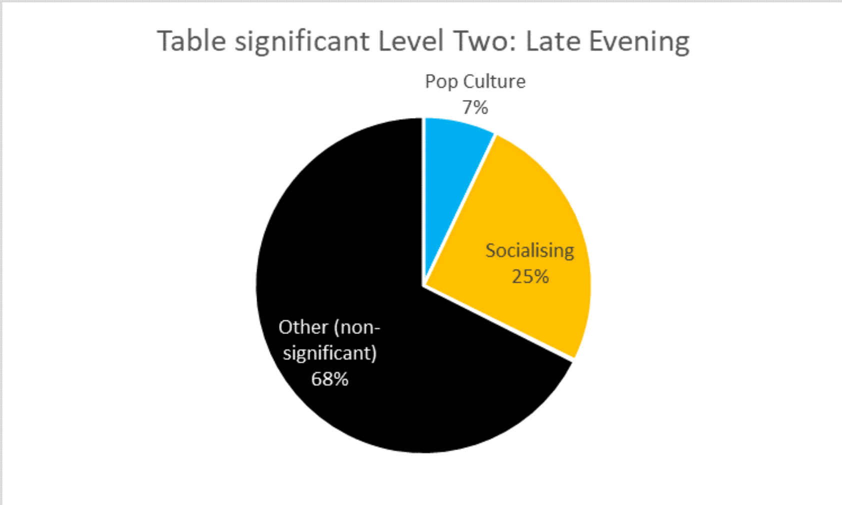


Figure 8.14 Significant Level-Two Deviations in the late evening

8.2.3 Different locations or situations and their influence on topics

Another important aspect of the analysis of the teacher training are the possible influences, that the locations or situations might have had on the topics that the participants and trainers talked about. A closer look at the different locations will help to form theories of how the location might or might not influence the topics of conversation. It is important to highlight that with the exception of the conference room (which to a large extend also shows conversations taking place inside the course sessions) the locations are typical locations in which informal conversations took place. It is also worth mentioning that naturally not all location-based analyses are based on the same amount of speaker codes as not in every location received the same amount of recordings. In order to compare the influences of locations in a sensible way the distribution of topics per location will be looked at. To give the reader a more comprehensive understanding of the influences of situational contexts also the situational data are incorporated in the text when it is meaningful. Also, the amount of speaker codes the location- and situation-based analysis is founded on will be presented.

Conference Room:

The conference rooms are the rooms inside of the University of Patras that both served as course rooms as well as rooms for breaks in between sessions. They are mid-size (30–40 people) to small rooms (15–25 people) containing chairs and tables.

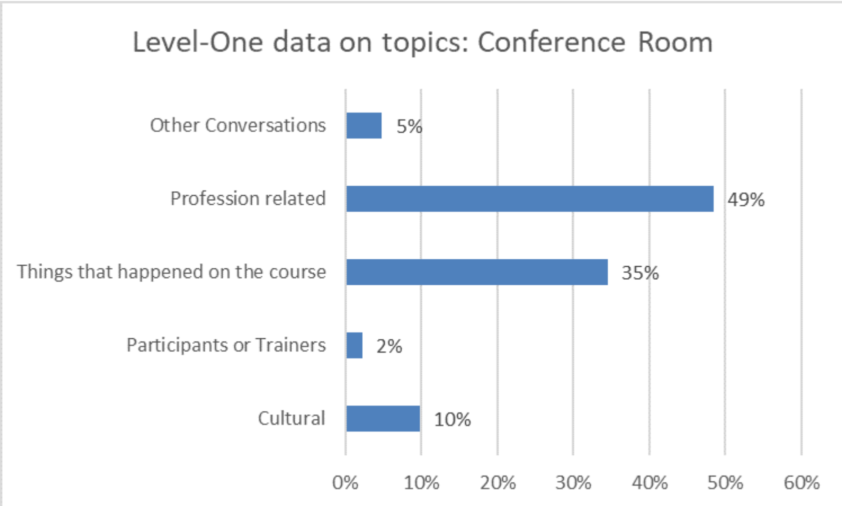


Figure 8.15 Level-One data on topics: Conference Room

In coffee-breaks coffee and tea were served. The analysis of communication inside of conference rooms is based on 2400 speaker codes. 1351 of the speaker codes were actual recordings inside the training course (see figures 8.18 and 8.19). As can be seen, the Level-One data mirrors the closeness of the location to the actual work sessions. This clearly seems to have an influence on the topics. The data shows that the profession related conversations roughly make up half of the conversations in that location as well as the things that happened on the course dominate. Looking at the data for profession related topics more closely we can identify two topics to dominate the informal conversations with regards to the profession:

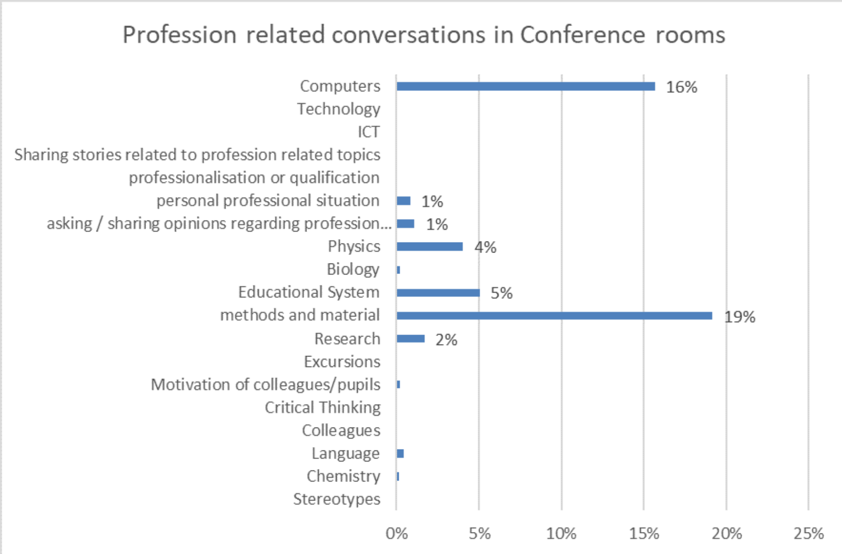


Figure 8.16 Profession related conversations in Conference rooms

The topic of Computers (16%) as well as the topic of methods and material (19%) are well above the other topics. The high levels of **"methods and material"** as well as **"Computers"** are congruent with the actual content of the teacher training course sessions.

Looking at the data directly the participants and trainers are mostly conversing about the methods and material they picked up in the course. In guided group-work settings they discuss how to use the acquired methods and materials in a sensible manner. Also, the speaker codes of computers make sense in that regard as the content of the entire course heavily revolved around computers. A closer look at the category "things that happened on the course" gives us a closer insight to the conversations that happened inside the "conference room". The Level-Two data shows the majority of speaker codes (26%) being attributed to planning. Looking at the data itself it becomes evident that all of the data codes with the Level-Two category: "planning" inside the conference room is referring to the planning of the participants inside the formal group work – as they are fulfilling their tasks.

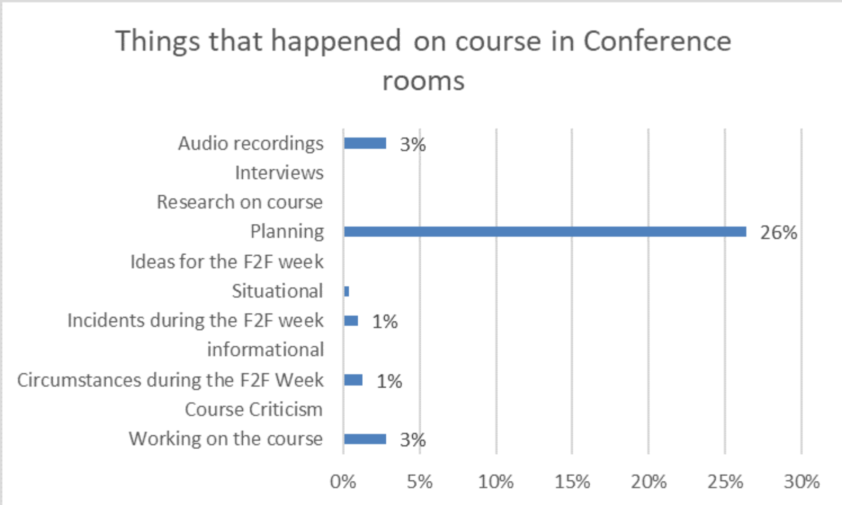


Figure 8.17 Conversations on things that happened on course in Conference rooms

Because of the significance of influence that a teaching session might have on the informal conversations of participants we want to take a closer look of the data that we have of right before the session, of inside the session and of right after the session. Unfortunately, the data that we have from "Before the Session" only contains 197 speaker codes. The data we have from inside the sessions are recordings from group works that participants recorded of themselves inside working sessions and contain 2030 speaker codes, the recordings at the end of session contain 484 speaker codes. Because of the different amount of recordings the data is hardly comparable but still may serve to emphasize the effects that a science teacher training course session from CAT had on the conversations taking place:

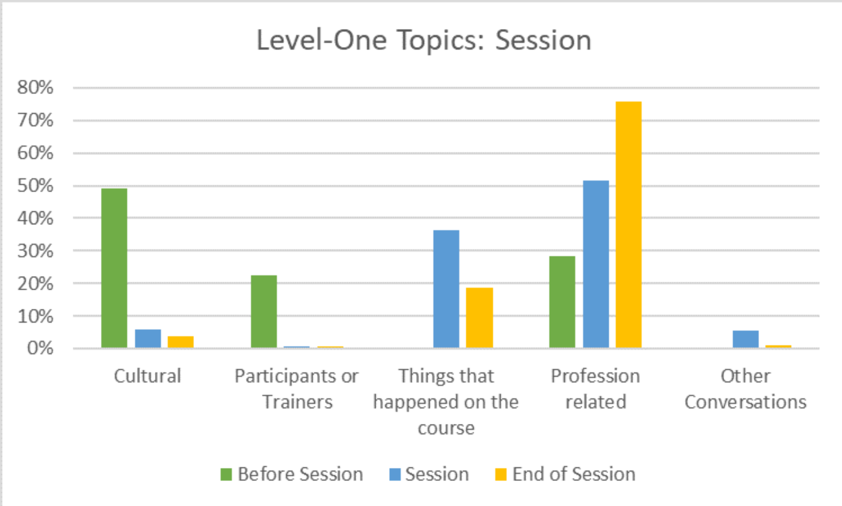


Figure 8.18 Level-One codes related to session situation

Taking a closer look at the data we found that the “Cultural” conversations were almost exclusively conversations around politics (41% out of the 49%). A look at the conversations shows that the conversations were inspired by recent world political events that were on the news at the time.

These conversations ended once the session was in progress and did not reappear at the end of session. Most interesting is the data around the “Profession related” conversations, which seemed to have been stimulated by the session itself. A look at the Level-Two codes shows:

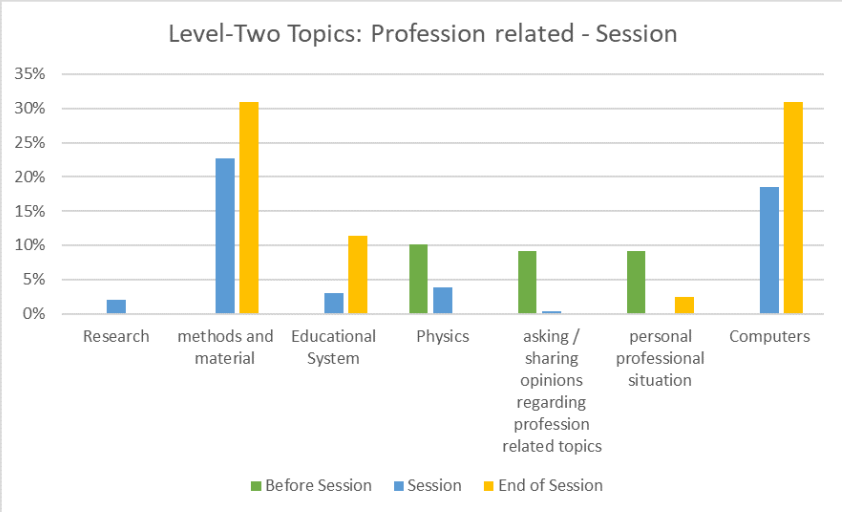


Figure 8.19 Level-Two codes related to Profession related conversations according to session situation

We can see that the session somewhat seems to interrupt conversations that happened before the session and replaces them with its own topics – only one of the topics "survives" the session and is picked up again after the end of the session: The conversation dealing with the "personal professional situation".

The session however seems to have inspired three informal conversations that did not exist before the session. These were conversations around:

- methods and material,
- computers,
- Educational System.

It is interesting to see that the session might act as a stimulus for profession related topics as much as it might act as an interrupt to other topics. Seeing that conversations around the "personal professional situation" are picked up at the end of the session, while having completely disappeared within the session, might be interpreted in the way that talking about the "personal professional situation" right at the end of the session is important to the participants and permeates their professional thinking as well as their informal domain. We would like to propose the idea that the "personal professional situation" might be a valuable starting point for the science teacher training sessions themselves as it seems to naturally occur around the teacher training sessions as well as it marks the 5th most popular theme in informal Level-Two codes over the week (see 8.1). We can see the profession related topics of “methods and materials” as well as “Computers” to represent the session content, which increases once the participants are able to openly converse among each other. The seemingly increased need to talk about the session content might point a science teacher training course designer to arrange a suitable space to be able to freely exchange on the session’s inputs.

Bar:

The bar refers to the bar inside of the respective hotels. The conversations in bars were recorded in the late evenings. The data in the bar is based on the same 3543 speaker codes that were documented in the analysis of the late evening (see page 185). Conclusively, all analyses that apply to the late evening also apply to the location: Bar.

(Hotel-)Restaurant:

The analysis of this location is based on 11895 speaker codes for the hotel’s restaurant and on 18289 speaker codes for all other restaurants and thus constitutes a very large dataset of informal conversations. We believe that the increased number of recordings is due to two reasons:

- the restaurant very clearly was identified by the participants as an informal space
- the restaurant is easily recorded, because participants are sitting and the recording device can easily be placed

The hotel restaurant was visited predominantly in the evenings and all other restaurants mostly in the afternoon or in the evenings. As can be seen in figure 8.20 the restaurant seems to provide a space for a great variety of conversations. Looking at Level-Two data regarding the strong Cultural conversations inside restaurants (see figure 8.21), we can see that *“Language”* and *“General exchange on culture”* as well as *“Politics”* were prominent topics inside restaurants. Inside the conversations we find that situational factors like looking at the menu and sitting next to colleagues from a variety of countries often lead to conversations about language. Even events like a running TV in the background are capable of sparking a conversation. This for us again is a strong indicator of the environment having some influence on informal conversations.

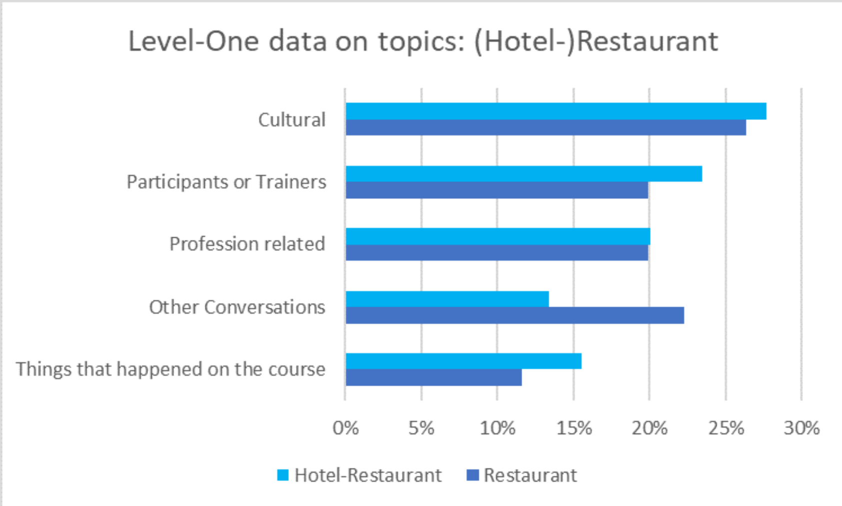


Figure 8.20 Level-One data on topics: (Hotel-)Restaurant

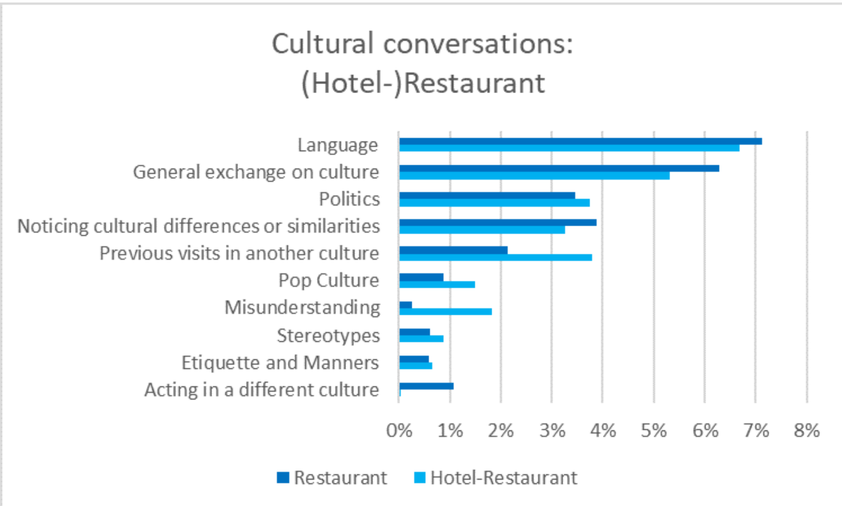


Figure 8.21 Cultural conversations inside (Hotel-)Restaurant

Looking closer at the restaurant conversations around participants and trainers (see figure 8.22) inside restaurants, we can see that the exchange of humorous remarks as well as of opinions seems to be of importance. They also seem to use the time to share more personal information.

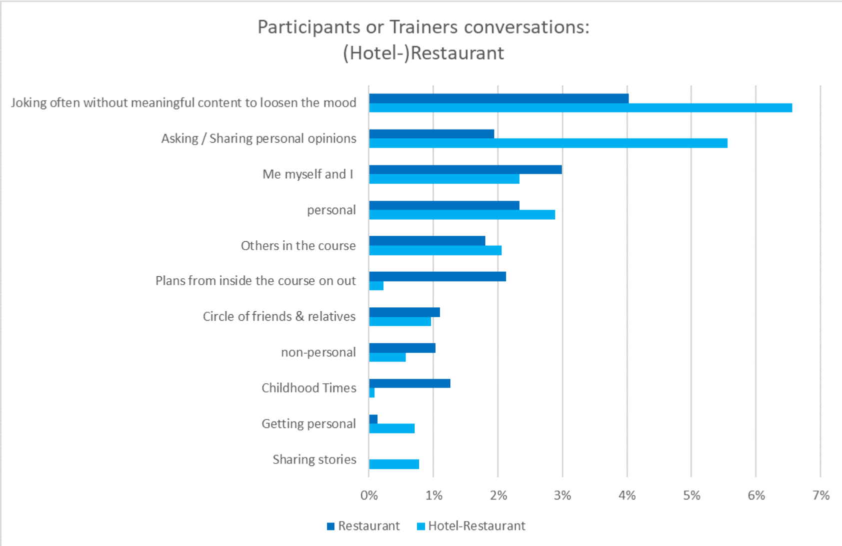


Figure 8.22 Conversations of Participants or Trainers inside (Hotel-)Restaurant

The profession related conversations in restaurants (see figure 8.23) are predominantly circling around the personal professional situation, in the hotel's restaurant, which was mostly visited in evenings, the conversations also contained a stronger aspect of sharing profession related stories. The other restaurant visits mostly occurred in the afternoon just after the sessions. We believe that the chronological proximity to the sessions might make a difference rather than the location. Quite possibly the evening and the location of the hotel for our participants were associated more with relaxation and possibly with getting to know each other better, while the afternoon visits still show more impact from the work session leading to slightly higher values in topics like “Physics”, “methods and material”, “Biology”, “Computers” and “Technology”.

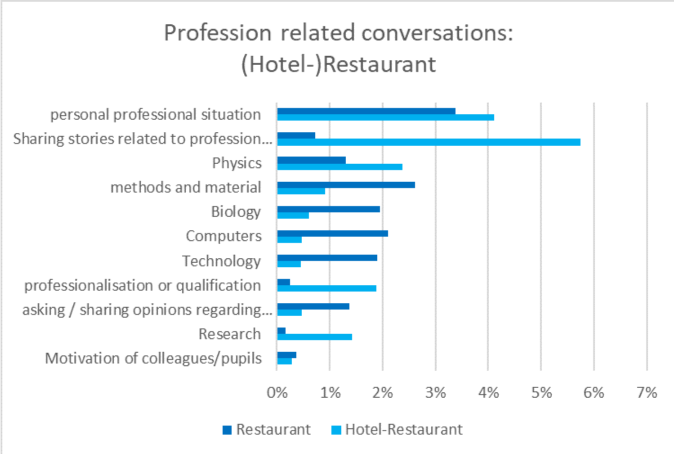


Figure 8.23 Profession related conversations inside (Hotel-)Restaurant

Primary School:

The participants primary school visit on Tuesday morning (see table 5.1) is based on 998 speaker codes. The Level-One topics distribute in the following way:

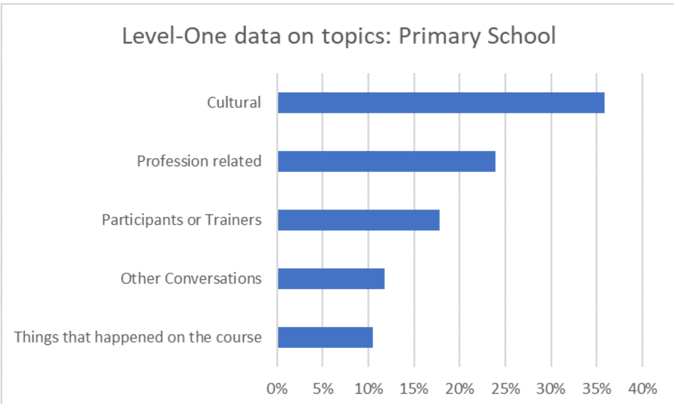


Figure 8.24 Level-One data on topics: Primary School

In the cultural domain we find many conversations around “Art”, which were derived from a seemingly arbitrary conversation on the musical tradition in

Portugal. The relatively high rank of the code "Noticing cultural differences or similarities" which interestingly did not show direct relations to the school visit.

Profession related conversations were also stimulated by the visit of the primary school and lead to increased informal conversations on the different Educational Systems. The visit also sparked conversations about the learning opportunities of "Excursions" which resulted in individuals sharing their concepts and plans for excursions in general.

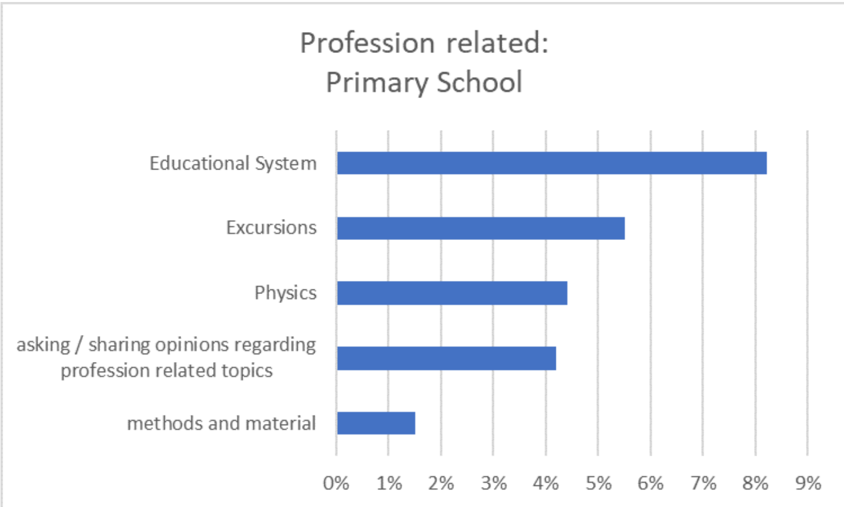


Figure 8.25 Profession related conversations inside the Primary School

Communication on Ways:

It is not entirely clear how informal conversations are unfolding on the way from A to B, be they by foot or by van. Several analyses have been conducted, whether or not the form of transport showed a significant impact on the topics addressed. The only conclusive correlation that may point to an impact on the topics was the correlation with time (see figure 8.26).

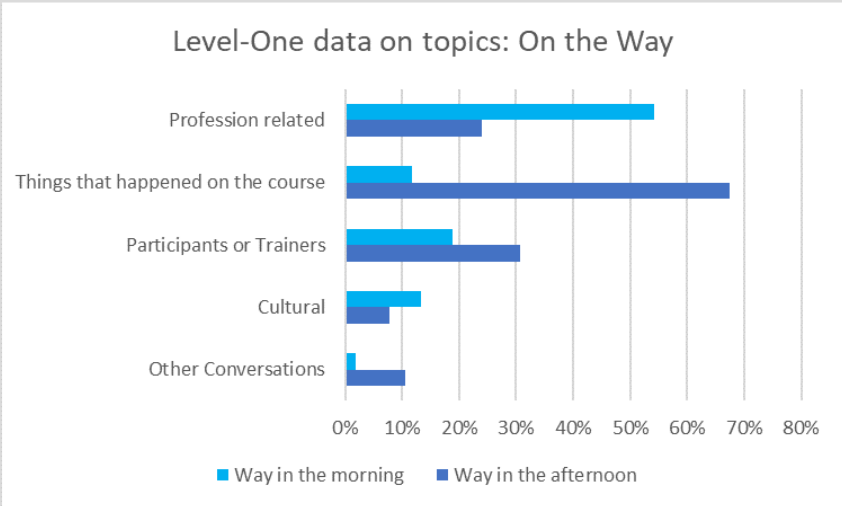


Figure 8.26 Level-One data on topics: On the way morning and afternoon

We think that the data as before may indicate a general decrease of profession related conversations over the day.

CHAPTER 9

RESULTS TO RESEARCH QUESTION 2: EVOLUTION OF COMMUNICATION

In this chapter we will present our findings with regards to the evolution of communication between individual participants. We are trying to look for patterns that determine the structural behaviour of group in terms of their communication. We will start by analysing the complete communicative network over the whole week and then analyse the development of the network. The methodological tools have been described in detail in section 7.2 on page 137.

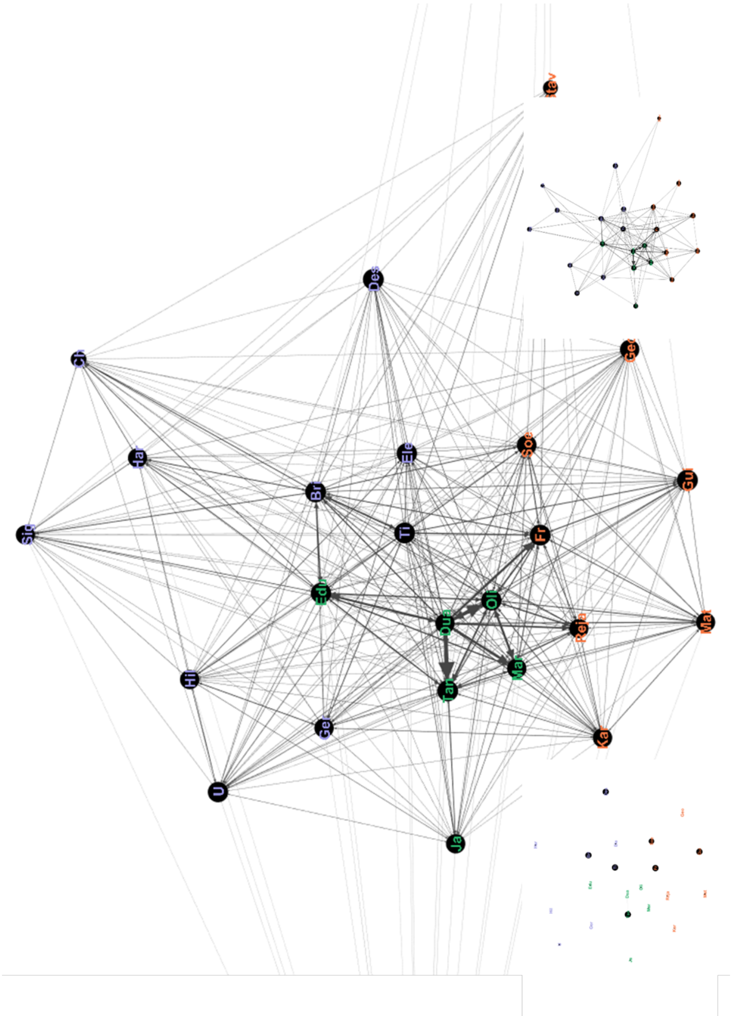


Figure 9.1 Force Atlas Layout for the complete communication over the whole week. Size is eigenvector centrality. Colour is modularity. Lower Left image marks betweenness centrality via size. Lower right marks filtered view.

9.1 The whole week

In the communication over the whole week the modularity algorithm found three clusters, that communicatively are closely connected:

Table 9.1 Communication Groups over the whole week

Cluster 1	Cluster 2	Cluster 3
Ja	Sig	Kar
Tan	Ch	Reja
Edu	U	Fr
Dua	Hil	Soe
Oli	Har	Mat
Mar	Ger	Gui
Man	Bri	Geo
	Ti	Stav
	Ele	
	Des	

In terms of components (cf. subsection 7.2.3) the network throughout the week can be described as a **connected** network, with every node being in touch with every other node.
This does not seem to be restricted to the level of communication over the whole week, but also applies to individual days as we will be able to see in the following subsections.

We would like to suggest the hypothesis that the connected networks are one characteristic of longer, dedicated, international science teacher trainings. We believe that Granovetter's theories (see page 46) might be a strong argument for international science teacher trainings to be places of increased communication across weak ties. We also would like to suggest that dedicated international science teacher trainings may encourage international communication: Removing science teachers from their familiar local contexts[1] may be a form of self-induced isolation and at the same increase the chances for immersion, while eliminating factors of distraction.

[1] Which is often the case in international science teacher trainings at least for some of the participants.

Cluster 1

In cluster one: Tan, Dua, Mar and Oli are the most communicative elements that are in close proximity of each other signifying a highly communicative relationship between each other. Looking at the betweenness centrality on the lower left of figure 9.1 we can recognize the strong clustering between those nodes not only through the high communication but also through the low betweenness centrality among them: The group while highly interactive within group members has a tendency to slightly isolate itself from the other participants. In a more disconnected network Tan and Edu and from Cluster 3: Fr according to their betweenness centrality would secure a vital part of the general flow of information into the cluster.

Looking at the four main actors of cluster one, we can find signs of **Homophily** (see subsection 7.2.3 on page 147ff.). Three out of the four participants come from the same nation, they also are in the same age group (30 to 40 years old).

Cluster 2

Cluster two contains three elements that have moved closer into the centre and are close to each other: Ti, Bri and Ele seem to be closely related with Edu acting as an equally close bridge to cluster one. The communication between the elements is not of the same intensity compared to the core members of cluster one. Here also **Homophily** seems to play a role as Ele, Bri and Edu are of same nationality, Ele, Bri and Ti roughly share the same age group (40 to 50 years old) with Ti being a little above 50 years old.

Another group attributed to cluster two are U, Hil and Ger. Here also **Homophily** with regards to age group seems at play (50 to 60 years old), additionally U and Ger are of the same nationality. Hil knows a little of the mother tongue of U and Ger.

A third group inside of cluster two can be found in the outer rim – signifying either a less communicative behaviour or merely less registered recordings of said participants. Sig, Har and Ch, while speaking the same mother tongue, are of different age groups.

Cluster 3

Cluster three has three elements to the centre: Fr, Reja and Soe and four elements further outward: Kar, Mat, Gui and Geo. Again, **Homophily** seems to play a certain role as Kar, Reja, Fr, Mat and Gui are from the same country. Regarding the age group, Kar, Reja Fr are in the same age group (40 to 50 years old) while Mat, Gui and Soe are in another age group (30 to 40 years old).

Preferential topics within the clusters

Regarding the clusters, we can analyse the topics that the participants talked about most and try to see, whether the members of certain modularity clusters show preferences for specific Level-One or Level-Three topics. It is interesting to see that the most communicative group inside cluster one is also the group that we know to have remained in touch after the end of the teacher training course and at least in one case visited each other well after the training had ended. It may be the case that a high grade of clustering of nodes inside the network possibly paired with a somewhat lowered betweenness centrality inside the cluster could point to certain participants *"having found each other"* and feeling sympathy for each other inside the teacher training course and consequently predominantly seeking each other's company. In case certain forms of sympathy are found to be recognizable either by means of their communication structure or by means of sociometric tests it could be beneficial to know whether these structures are found to be a predictor for the sustainability of groups beyond the life time of teacher training courses.

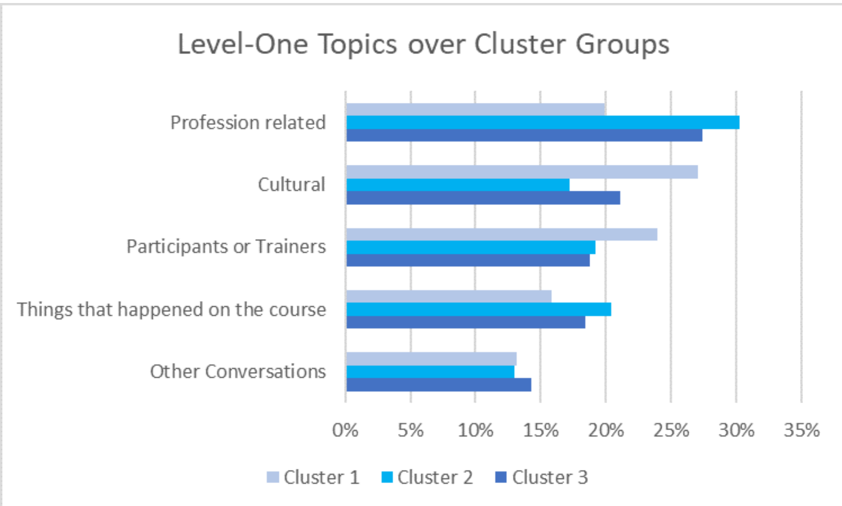


Figure 9.2 Level-One topics

Because of the significantly different structure of cluster 1 and especially their respective sub-elements[2], we will pay special attention to the communicative preferences of cluster 1. In figure 9.2 we can see that the most communicative cluster 1 shows differences with respect to some of the topics. It seems that cluster 1 in comparison showed a higher percentage of *cultural* communication and less *profession related* conversations. Also with regards to the Level-One category *"Participants and trainers"* the group seems to differ to a certain degree compared to cluster 2 and 3. Apart from these differences the clusters do not differ too much with regards to Level-One categories. Looking at the cultural conversations in more detail we find that:

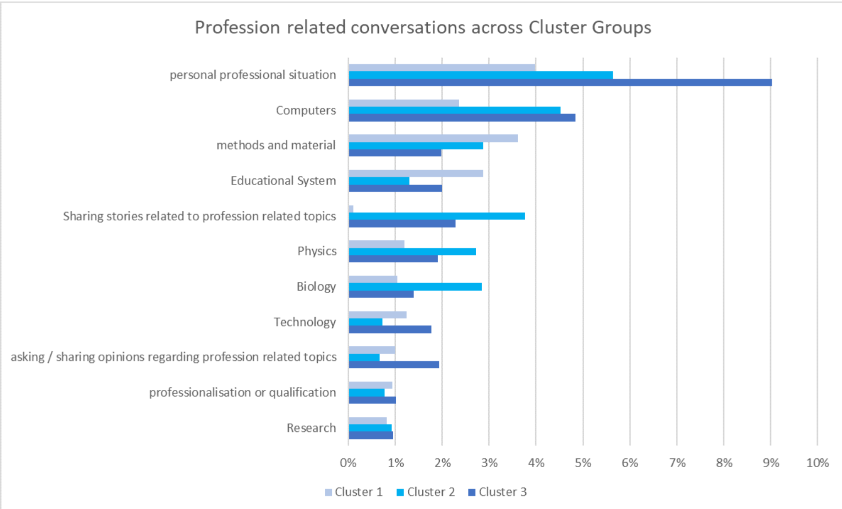


Figure 9.3 Level-Two codes profession related

In figure 9.3 we can see that despite *"personal professional situation"* being the largest item for all three clusters, the degree by which it dominates the profession related conversations is quite different for all clusters. The second largest item for clusters two and three is *"Computers"*, which is approximately on the same level of just under 5%. The same category only ranks fourth for members of cluster one. For cluster one the discussion of *"methods and material"* and **"Educational System"** seems more important. *"methods and material"* and **"Educational System"** take rank third and fourth for clusters two and three. Interestingly

[2]Especially the highly communicative elements to the core.

unlike cluster two and three, cluster one was not recorded in communication on *"Sharing stories related to profession related topics"*.

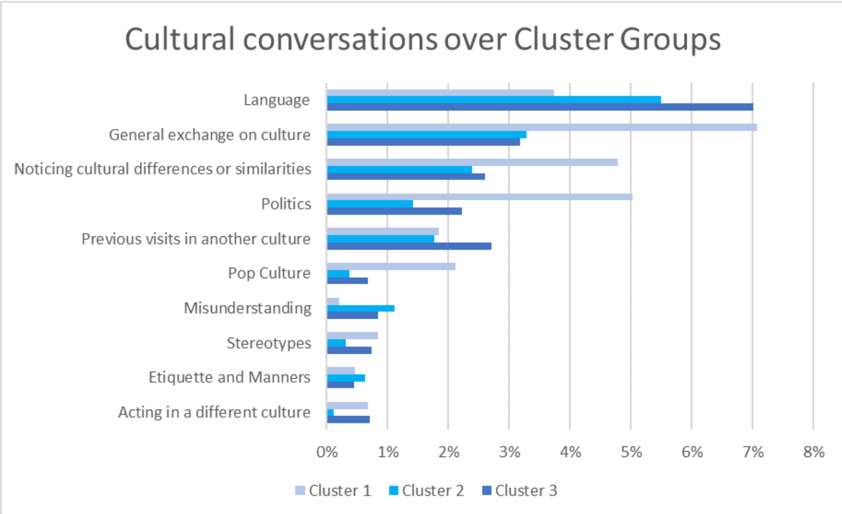


Figure 9.4 Level-Two codes cultural

In figure 9.4 we can see cluster one to indeed have a different profile. There seem to be less *"language"*-oriented conversations. It has to be stated however that in terms of communication about *"language"* every cluster had their own profile.

In cluster one there seem to be a lot more conversations dedicated to *"General exchange on culture"*, *"Noticing cultural differences or similarities"*, *"politics"* and *"pop culture"*. With regards to figure 9.5 (see the following page), it has to be stated that humorous remarks were considerably higher amongst members of cluster one. This observation raises interesting questions with regard to the function of humour. There are several possible hypotheses to be formed. Shared humour could be regarded as an expression of sympathy and familiarity. Yet it might as well be that humour is seen as an individual's tool to create sympathy and familiarity. It could also be that humour is a typical character trait of especially communicative people. Further research could help to see whether the observation of humour can be used to explain certain group dynamic processes running in the background.

The observable differences between cluster one and the other clusters raise some questions with regard to the effects of clustering inside teacher trainings itself.

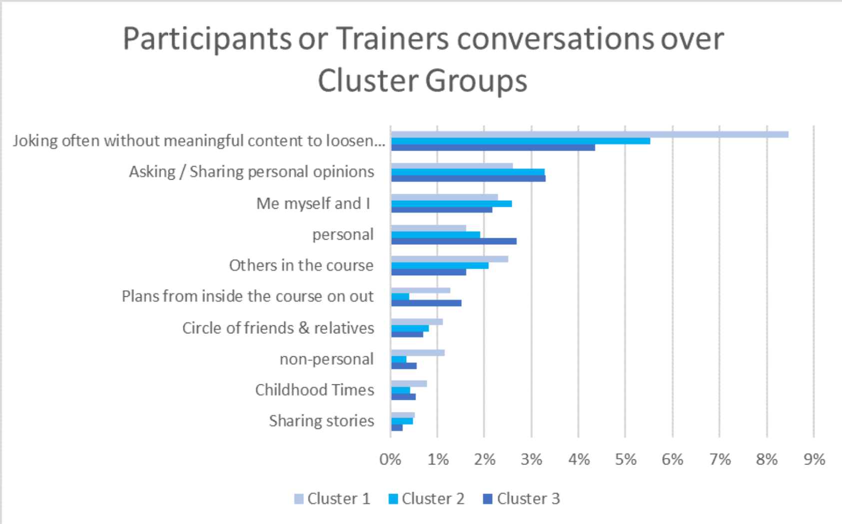


Figure 9.5 Level-Three code participants and trainers

There is currently little information on whether strong clustering poses more of a risk or rather a chance for the science teacher trainings. While in terms of group-dynamic processes a greater factor of clustering might be viewed as being exclusive of other participants and be judged critically, it might also prove to be highly beneficial in terms of the sustainability of a group beyond the life time of the training. As long as the network remains well **"connected"** clustering could turn out to be a positive development inside courses that help building a sustainable network that can be implemented in extended concepts of PD.

9.1.1 Monday

	Ch (m) GER	Sig (m) GER	Mat (m) FRAN	Ger (m) GER	Har (m) AT	Oli (f) AT	Hila (f) FIN	Bri (f) GER	Edu (m) GER	Tan (f) POR	U (f) GER	Ele (f) GER/GF	Dua (m) POR
Total Today	0	124	149	765	155	3078	1737	3365	3210	2908	514	1322	6595
Average per Day	301,6	304,8	700,8	788,2	536	2879	713,8	1907,2	1813	1448,4	436,2	762,4	4319,4

Gui (m) FRAN	Ti (m) FIN	Fr (m) FRAN	Mar (f) POR	Kar (f) FRAN	Alex (f) GRE	Stav (f) GRE	Reja (f) FRAN	Ja (f) BUL	Geo (m) GRE	Des (f) GRE	Soe (m) GER	Man (f) GER
769	5142	3447	2429	467	27	935	1223	990	1048	666	1247	350
554,6	1989,4	1904,6	1394,6	961,8	5,4	209	1202,2	571,6	530,2	383,8	1054	89,6

Figure 9.6 Quality estimate per person – how many speaker codes were registered per person on Monday.

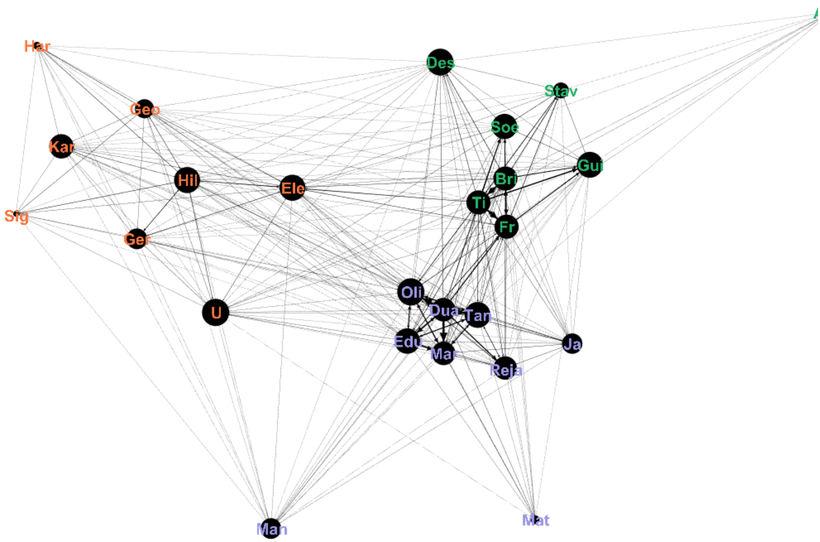


Figure 9.7 Network of directed conversations on Monday on Forced Atlas display including eigenvector centrality (size) and modularity (colour) effects.

The network structure on Monday is based on 10745 speaker codes and is calculated by 42662 speaker turns.

The component aspects of the communicative network again point to a **connected** network. Looking at a filtered view we can see that the network looks different once we filter out all speaker turns below the 150 turn mark: Here we can clearly see that the network is a little more dispersed.

The network shows the close proximity of several nodes that heavily interact with each other. The modularity algorithm identifies three different groups. We start with the group that is in closest interaction with each other. The group consist of eight nodes representing eight people. **Oli, Dua, Tan, Edu** and **Mar** seem very closely interconnected – **Reja** and **Ja** are also close but in some distance. The filter shows, that **Man** has less than 150 turns to any one single person (and only 350 in total on Monday) and is also in a greater distance from that group. The next group consist of seven persons **Bri, Ti, Fr** are the closest persons with **Gui** and **Soe** also close by. Of this group **Des** and **Stav** are farthest away. The final group contains eight individuals that are more loosely connected. Of this group only **Hil**, Ger and **Ele** are connected with over 200 turns **U, Geo**, Kar, Sig and Har are further away. **Stav**, Har, Sig and Mat[3] are visibly lower in terms of eigenvector centrality – Ch is not even on the graph at all. This must not be mistaken for an outsider's position. As we can see from the table above the graph it simply means that there are less recordings available of the people in greater distance to the centre – for that day. As mentioned before due to the methodology applied the absence or lack of information does not constitute an information as such.

Since people have different communication styles, one way of "correcting" the graph in order to take into account that different people communicate to different degrees and were recorded to different degrees – is to display a "relative" instead of an "accurate" picture of the conversational connections between individuals by dividing each turn from one person towards another by the number of turns the person was recorded on that day and in this way decrease the weight of persons that were recorded a lot and increase the weight of persons that were recorded a lot less on that particular day. Doing so displays the weighs of the individual's choice to speak to another person more equally, not depending so much on the total amount of the spoken word by each individual, yet by the relative amount of the individual's spoken word compared to itself.[4] As can be seen in figure 9.8 the formation of groups through the individual choices rather than the quantity of speech is highlighted in this mode of view.

Focussing on the results of the betweenness centrality algorithm by Brandes [2001] in figure 9.8 we can see that some persons on Monday were important to connect different parts of the network. The major nodes associated with betweenness centrality on Monday are **Des** and **Soe** also important are **Oli**, **Edu**

[3]Mat is located to the bottom right part of the graph not visible on the depiction.

[4]Still this result suffers from a minor distortion that comes through a person being less recorded, being also less addressable by other subjects resulting in a more outward position with less connections to other nodes. This evidently also has a negative effect on eigenvector centrality.

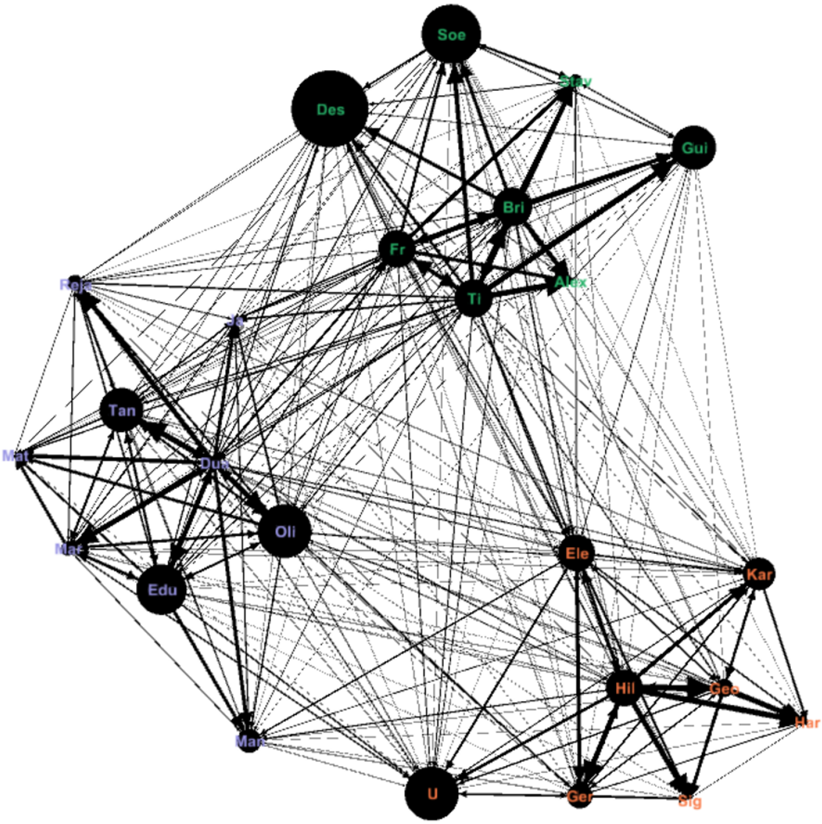


Figure 9.8 Relative turns between individuals on Monday in a Forced Atlas view with betweenness centrality (size) and modularity (colour) effects. The edge weight scale has been maximized.

and **U**. These actors regarding to their position in the network played an important role in having information travel through the network and keeping it permeable.

It is important to reflect that since most of the recordings on Monday were recorded in the evening (see table 2.1), they were according to the schedule (see table 5.1) heavily shaped by the location of the restaurant of the "Welcome dinner" to an unknown degree.

9.1.2 Tuesday

	Ch (m) GER	Sig (m) GER	Mat (m) FRA	Ger (m) GER	Har (m) AT	Oli (f) AT	Hila (f) FIN	Bri (f) GER	Edu (m) GER	Tan (f) POR	U (f) GER	Ele (f) GER/G	Dua (m) POR
Total Today	1124	1134	952	1190	1996	2565	1496	4305	5007	1076	1047	1618	4050
Average per Day	301,6	304,8	700,8	788,2	536	2879	713,8	1907,2	1813	1448,4	436,2	762,4	4319,4

	Gui (m) FRAN	Ti (m) FIN	Fr (m) FRAN	Mar (f) POR	Kar (f) FRAN	Alex (f) GRE	Stav (f) GRE	Reja (f) FRAN	Ja (f) BUL	Geo (m) GRE	Des (f) GRE	Soe (m) GER	Man (f) GER
	556	2855	482	995	1373	0	110	940	487	223	249	1709	82
	554,6	1989,4	1904,6	1394,6	961,8	5,4	209	1202,2	571,6	530,2	383,8	1054	89,6

Figure 9.9 Quality estimate per person – how many speaker codes were registered per person on Tuesday.

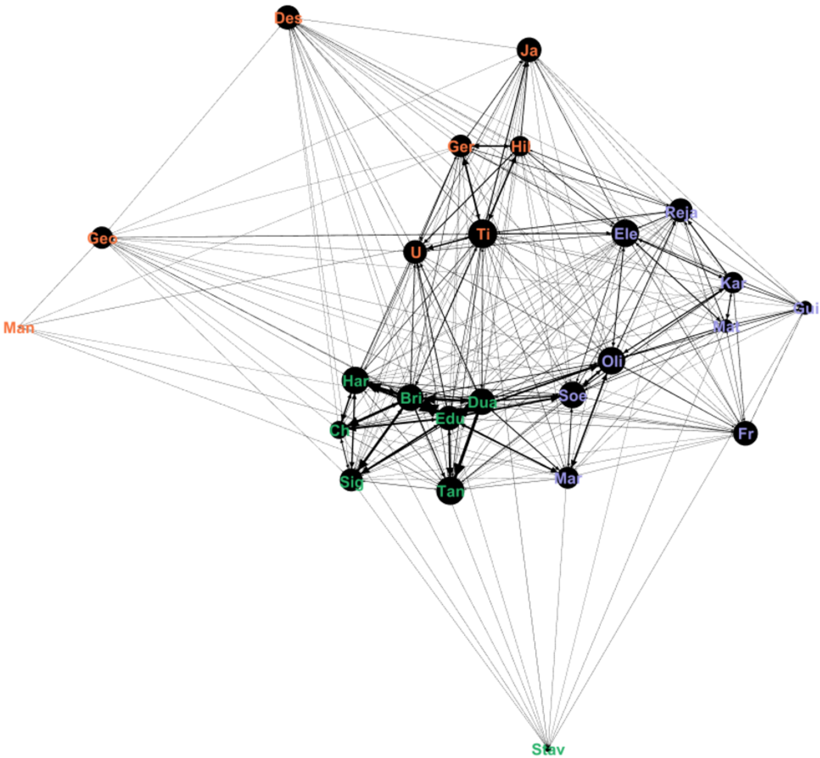


Figure 9.10 Network of directed conversations on Tuesday on Forced Atlas display including eigenvector centrality (size) and modularity (colour) effects.

The network structure on Tuesday is based on 10276 speaker codes and is constructed using 37621 speaker turns. Again, the modularity algorithm identifies three different groups. We start with the group that is in closest interaction with each other. The group consist of eight nodes representing eight people. Dua, Tan, **Edu** remain in one group and are heavily interacting – with **Bri**. Reja and Ja seem to have moved on and are now counted towards a different group. **Bri, Har, Ch and Sig** seem to have been adopted by the cluster one, whereas **Bri** seemingly comes from a different group than **Sig** and **Har**. **Ch** had not been recorded on Monday.

Bri and **Edu** come from the same school and are colleagues outside of the teacher training course. While having had little communication on record on Monday they ended up communicating quite intensely on Tuesday. It appears as if **Bri** and **Edu** are both communicating in the direction of **Har, Ch, Sig** and in the direction of some of the highly communicative subgroup in the original cluster-one (**Dua, Tan, Edu**), thus drawing both groups closer together. The communication pattern of **Bri** for the first two days could possibly be described as explorative, trying to mingle with different types of people while also associating with the persons she knows well. An interesting change has occurred with Oli and Mar who have been on record a little less than their daily average. Mar's movement to the outskirts of the network is probably due to her being less recorded. Oli who has only a little less than her average recorded speaker codes has seemingly moved closer to **Soe** who himself moved closer to the original cluster one.

The cluster around **Ger, Hil, U** seems like a continuation of a communicative process that had started on Monday with a minor change: **Ti** who is a colleague of **Hil** communicatively joined the group. This group is marked by **Homophily** with regards to their age group (50–60 years old). And all of the participants of this group seem to be culturally interested in **U's** and **Ger's** mother tongue.

The group **Kar, Mat, Gui, Ele** and Reja mark a third group that is communicatively engaged, with the exception of **Ele** all members of the group share the same country of origin. Three of them come from the age group (40–50 years old) (Reja, **Kar, Ele**) and two of them from the age group (30–40 years old) (**Mat, Gui**).

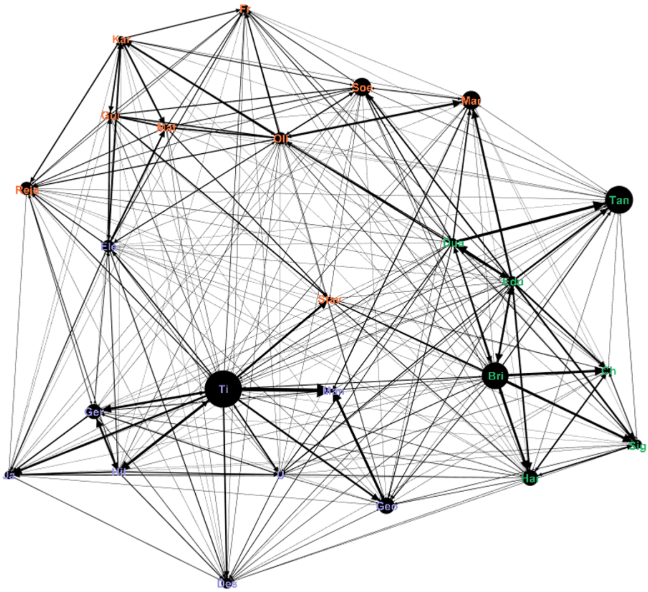


Figure 9.11 Relative turns between individuals on Tuesday in a Forced Atlas view with betweenness centrality (size) and modularity (colour) effects.

In figure 9.11 we can see some of our descriptions confirmed: By being interested in communicating with different partners (also compared to Monday) **Br** and **Ti** gain increased importance inside the network in terms of betweenness centrality. Our highly communicative cluster one members (with the exception of Tan) in terms of betweenness centrality stuck to a more self-absorbed communication pattern showing little openness.

9.1.3 Wednesday

	Ch (m) GER	Sig (m) GER	Mat (m) FRA	Ger (m) GER	Har (m) AT	Oli (f) AT	Hila (f) FIN	Bri (f) GER	Edu (m) GER	Tan (f) POR	U (f) GER	Ele (f) GER/G	Dua (m) POR
Total Today	247	220	143	633	524	2240	105	1618	779	319	116	71	2751
Average per Day	301,6	304,8	700,8	788,2	536	2879	713,8	1907,2	1813	1448,4	436,2	762,4	4319,4

	Gui (m) FRAN	Ti (m) FIN	Fr (m) FRAN	Mar (f) POR	Kar (f) FRAN	Alex (f) GRE	Stav (f) GRE	Reja (f) FRAN	Ja (f) BUL	Geo (m) GRE	Des (f) GRE	Soe (m) GER	Man (f) GER
	498	1436	903	482	614	0	0	933	966	128	64	244	0
	554,6	1989,4	1904,6	1394,6	961,8	5,4	209	1202,2	571,6	530,2	383,8	1054	89,6

Figure 9.12 Quality estimate per person – how many speaker codes were registered per person on Wednesday.

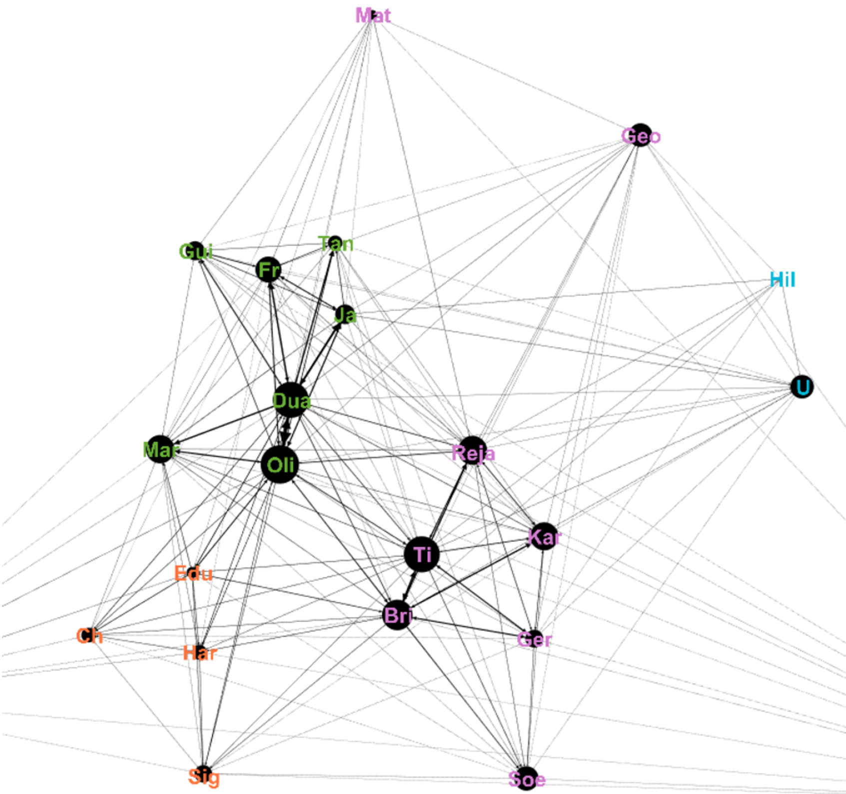


Figure 9.13 Network of directed conversations on Wednesday on Forced Atlas display including eigenvector centrality (size) and modularity (colour) effects.

The network structure on Wednesday is based on merely 4217 speaker codes and is constructed using 16034 speaker turns, which is less than half compared to the amount of speaker codes and speaker turns on Monday and Tuesday. The sociogram is made of 16034 distinct speaker turns. This relatively thin database means that the interpretation of this sociogram is unlikely to represent the communication activities on that day. Still it is surprising to see that even within this relatively small excerpt that was recorded still some of the communicative relations that could be seen on other days can be found within this sociogram as well. The modularity algorithm identifies four different groups.

The sociogram on Wednesday shows close communicative connections between Dua, Oli and Mar. Also Fr, Gui, Ja and Tan seem to be in communication with each other. Another greater cluster seems to be made up of Ti, Bri, Kar and Ger. The last cluster that is not too far out is Ch, Edu and Har. The fourth cluster detected by the modularity algorithm consists of two people only Hil and U that used to be in the same cluster on Monday and Tuesday also.

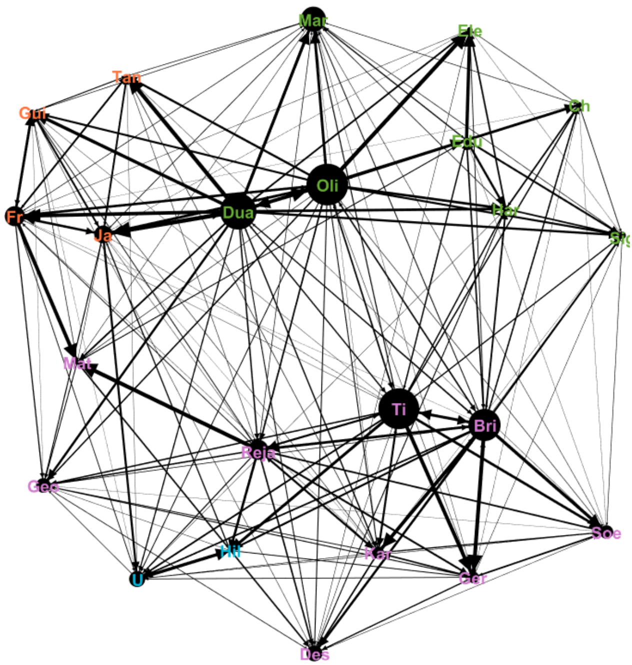


Figure 9.14 Relative turns between individuals on Wednesday in a Forced Atlas view with betweenness centrality (size) and modularity (colour) effects.

9.1.4 Thursday

	Ch (m) GER	Sig (m) GER	Mat (m) FRA	Ger (m) GER	Har (m) AT	Oli (f) AT	Hila (f) FIN	Bri (f) GER	Edu (m) GER	Tan (f) POR	U (f) GER	Ele (f) GER/G	Dua (m) POR
Total Today	8	11	2256	1347	0	6416	231	240	59	2939	494	801	8156
Average per Day	301,6	304,8	700,8	788,2	536	2879	713,8	1907,2	1813	1448,4	436,2	762,4	4319,4

	Gui (m) FRAI	Ti (m) FIN	Fr (m) FRAN	Mar (f) POR	Kar (f) FRAN	Alex (f) GRE	Stav (f) GRE	Reja (f) FRAI	Ja (f) BUL	Geo (m) GRE	Des (f) GRE	Soe (m) GER	Man (f) GER
	780	428	4553	3067	2325	0	0	2887	415	1252	936	1847	16
	554,6	1989,4	1904,6	1394,6	961,8	5,4	209	1202,2	571,6	530,2	383,8	1054	89,6

Figure 9.15 Quality estimate per person – how many speaker codes were registered per person on Thursday.

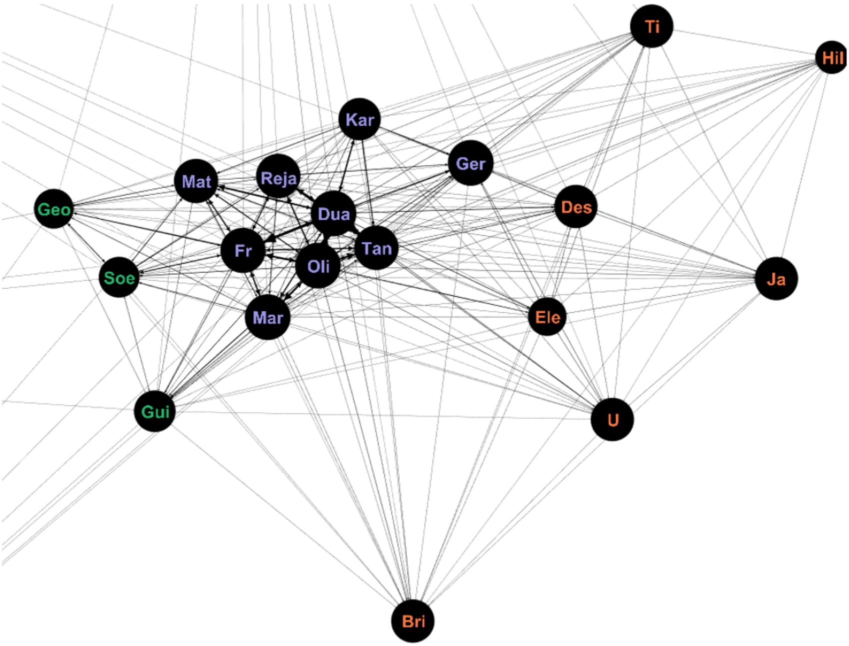


Figure 9.16 Network of directed conversations on Thursday on Forced Atlas display including eigenvector centrality (size) and modularity (colour) effects.

The network structure on Thursday is based on 10252 speaker codes and is constructed using 41464 speaker turns. As the network structure on Wednesday is unreliable we will compare the network structure on Thursday with the network structure on Tuesday.

The structure on Thursday seems somewhat denser. Looking at table 2.1 we can find that from the recording times Thursday is quite comparable to Monday, while Tuesday and Wednesday seem to be focussed with recordings mainly between 12:00 and 15:00. The modularity algorithm reports a supercluster in the middle that is made of conversations between **Dua, Tan, Oli, Mar, Fr, Reja, Mat, Kar, Ger**. Compared to Tuesday the subgroup **Kar, Mat, Fr, Reja, Oli** seem to have communicatively merged with the group **Dua, Tan, Mar**. The group **Geo, Soe, Gui** is closely related yet communicatively in some distance. **Des, Ele, U** seem to form another cluster that communicatively is also oriented towards the centre cluster. Since most of the day was recorded in the evening like on Monday the conversations might have been influenced by the setting of the Farewell dinner (see table 5.1) to an unknown degree.

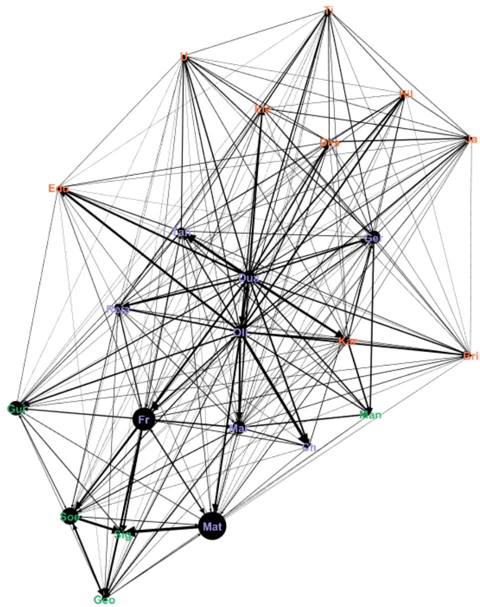


Figure 9.17 Relative turns between individuals on Thursday in a Forced Atlas view with betweenness centrality (size) and modularity (colour) effects.

The relative graph reveals **Mat** and **Fr** to have served an important function in keeping **Geo, Soe, Gui** informationally attached to the centre cluster. Ti and Bri who fulfilled a similar role on Tuesday unfortunately did not get recorded on Thursday.

9.1.5 Friday

	Ch (m) GER	Sig (m) GER	Mat (m) FRA	Ger (m) GER	Har (m) AT	Oli (f) AT	Hila (f) FIN	Bri (f) GER	Edu (m) GER	Tan (f) POR	U (f) GER	Ele (f) GER/G	Dua (m) POR
Total Today	129	35	0	5	5	83	0	8	10	0	8	0	0
Average per	301,6	304,8	700,8	788,2	536	2879	713,8	1907,2	1813	1448,4	436,2	762,4	4319,4

Gui (m) FRAN	Ti (m) FIN	Fr (m) FRAN	Mar (f) POR	Kar (f) FRAN	Alex (f) GRE	Stav (f) GRE	Reja (f) FRAN	Ja (f) BUL	Geo (m) GRE	Des (f) GRE	Soe (m) GER	Man (f) GER
170	86	138	0	0	0	0	28	0	0	0	223	0
554,6	1989,4	1904,6	1394,6	961,8	5,4	209	1202,2	571,6	530,2	383,8	1054	89,6

Figure 9.18 Quality estimate per person – how many speaker codes were registered per person on Friday.

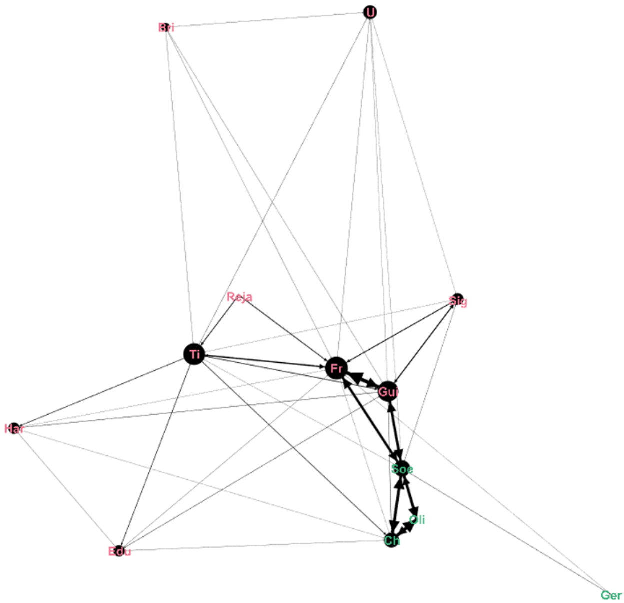


Figure 9.19 Network of directed conversations on Friday on Forced Atlas display including eigenvector centrality (size) and modularity (colour) effects.

The network structure on Thursday is based on 429 speaker codes and is constructed using 928 speaker turns. As can be seen from figure 9.18 almost no conversations were recorded. In table 2.1 we can see that the total recording time for Friday is 19 minutes. We will abstain from interpretation and include the network graph for reference purposes. A relative network graph has been calculated and can be found in the digital Annex of this work.

9.2 Attempts of Interpretation

Early connections prevailing

The group formation is a vital part of any teacher training. For the organiser of an international science teacher training it is important to form viable theories on the formation of groups. So by comparing the structure on Monday (figures 9.7 and 9.8) with the overall structure over the week (figure 9.1) we hope to find patterns that were established quite early in the face-to-face week and proved to be stable throughout the week:

Table 9.2 Modularity Algorithm over the whole week and over Monday. Differences are marked red in the column on Monday.

Whole Week			Monday		
Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3
Ja	Sig	Kar	Ja	Sig	
Tan	Ch	Reja	Tan		
Edu	U	Fr	Edu	U	Fr
Dua	Hil	Soe	Dua	Hil	Soe
Oli	Har	Mat	Oli	Har	
Mar	Ger	Gui	Mar	Ger	Gui
Man	Bri	Geo	Man		
	Ti	Stav	Reja		Stav
	Ele		Mat	Ele	Des
	Des				Bri
				Geo	Ti
				Kar	

Looking at the table 9.2 we can see that 17 out of 25 persons could be found in a cluster on the first day of recordings whose core would remain stable with regards to the communication over the entire week. We are confident that 70% of the communicative group formation had already manifested itself on the first day of the face-to-face week.[5] Interestingly, all persons that left their cluster ended up in a different cluster together: Reja and Mat both left cluster one and ended up in cluster three over the whole week. Geo and Kar left cluster two and ended

[5] Obviously this result needs to take into account effects caused at the day of the arrival, and effects of previous online contacts.

also in cluster three together. Des, Bri and Ti left cluster three and over the whole week ended in cluster two, together.

Since all participants had met online before and a few of them had planned and taken their trip to Patras, Greece together (for both also see section 5.3 on page 98), it is unknown to what degree parts of the network had already been established either virtually or on the trip to Patras taken together. It is worth mentioning that the subgroup of cluster one that communicated quite closely marks a group that had taken the trip to Patras together.

The implication of this observation is, that there is a likelihood of essential group formation processes, being visible quite early. It must be stated though that group formation is not the same as group stabilisation: It could be that groups can determine quite early, who their peers in terms of sympathy and interests are, yet that these groups still require a substantial amount of informal and dedicated time to become *"meaningful"* for each other and thus increase the chances of sustainability.

9.2.1 Hypotheses on group formation

We shall now try to form plausible hypotheses for the core groups to possibly have formed in the first place. Before we delve into commonalities that might be causes for group formation. We will look at relationships that existed before the beginning of the course. Three connections are worth mentioning:

Hil (f) – Ti (m):

Hil and Ti are colleagues at the same school in Finland. They are both aged 50+ and have worked together.

Tan (f) – Dua (m):

Tan and Dua at the time of the training course are a couple. Both at the time of the course were working as teachers in Portugal. Both at the time were in the age group 30–40.

Bri (f) – Edu (m):

Bri and Edu are colleagues at the same school in Germany. Edu is in the age group 30–40. Bri in the age group 40–50.

Two of these connections mark professional relationships, the third relationship is a couple. Only the close connection of the couple is reflected in the formation of the clusters. This data seems insufficient to draw final conclusions. However, the example of Tan and Dua allows for the hypothesis that very close relationships possibly are likely to remain in one communicative cluster throughout a teacher training course.

In order to form hypotheses on group formation we want to look at commonalities that might have resonated with our group constellation during our teacher training course.

Intralingual preferences

The mother tongues of participants and trainers inside the CAT course were distributed as follows:

Table 9.3 Participants & trainers according to their nationality

German	Austrian	French	Greek	Portuguese	Finish	Bulgarian
Ch; Sig; Ger; Bri; Edu; U; Ele; Soe; Man	Har; Oli	Mat; Gui; Fr; Kar; Reja	Ele; Alex; Stav; Geo; Des	Tan; Dua; Mar	Hil; Ti	Ja

By using the gathered matrices on speaker turns (see Appendix B Item 1a) we can determine the percentage that each participant or trainer communicated within their own language. In order to calculate this we can use the following formula with y being the total turn value for each participant or trainer of a specific mother tongue and c being the total number of participants/trainers of a certain country and $\sum x$ being the total turn value for all participants or trainers the person talked to and n being the total number of participants or trainers in the whole course:

$$\frac{\sum y}{c-1} * \frac{n-1}{\sum x} * 100 \tag{9.1}$$

The above formula gives us a preference of every single person to talk with a person of a specific mother tongue. We can then calculate the arithmetic mean of said values for all members of the same mother tongue, which we then can use to determine the average likelihood of a member of one language group to communicate with another member of the same language group. Repeat those steps with the matrices for every day, we yield the following results:

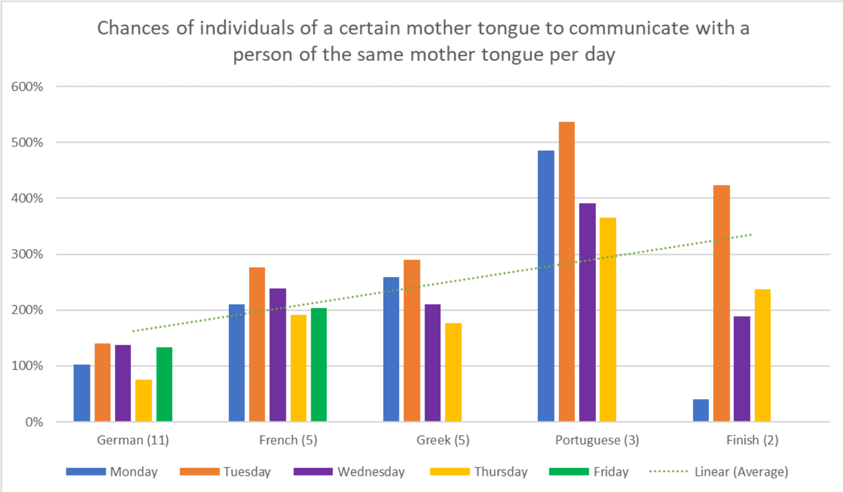


Figure 9.20 Chances of individuals of a certain mother tongue to communicate with a person of the same mother tongue per day. The number of persons speaking the same mother tongue is in brackets. Source: Own research.

This marks an interesting observation judging from the linear average the preference for "sticking" to people of the same mother tongue seemed to correlate with the number of persons available inside the same language group. The proverbial *"birds of a feather flock together"* in our course seemed to depend on the group size.

The observation at first glance seems counter-intuitive: If there were more persons available in the same language group, one would expect the chances of communication within this language group to be slightly higher – if communication was evenly distributed amongst all participants – compared to a language group with having less members. In our data we can observe the opposite: The smaller the group, the more likely it was, that the communication happened inside the group and the interlingual border was less likely to be crossed. Interestingly, with only two members in the language group the pattern in our course could not any longer be observed.

We suggest that the phenomenon described above could point to two factors:

1. **Security**
   The larger group speaking the same mother tongue might provide their members with a sense of security. This feeling of security might be the

basis for opening up to others. Furthermore, the members of the larger group can be sure that in case of communicative problems there is help from the language peers when needed. The smaller the group, the more it might feel somewhat isolated and communicatively insecure. Subconsciously, the question, why someone of the larger group would be likely to communicate with them, when they have enough of their own language peers to talk to, could be lingering. Also, without the benefit of the mother tongue as a fall-back language – they might be less likely to engage in interlingual communication confidently. Being part of a smaller group might also instil the social imperative of being there for one-another.

2. **Bridge building**
   There might also be effects of "bridge building": A larger group is more likely to cross the interlingual border and in doing so, may bring members of the same language group to also start communication with the contacts he or she established, thus allowing more communication with members of a different language group in total.

Naturally other interpretations are imaginable. One could ask whether or not in a group of 25 persons, we could be dealing with random effects. Since we have many recordings and can see the effects repeated over all of the days of the CAT science teacher training, we do not believe this to be the case. Of course, as the *"speaker turns"* were being determined algorithmically and thus were subject to errors (see subsection 7.2.1), there might be distortions with regards to the magnitude of the effect. Yet also here we suspect the error to affect all language groups to more or less the same degree.

Age preferences

The age of participants and trainers inside the CAT course was distributed in the following manner:

Table 9.4 Participants & trainers according to their age [years]

30–40	40–50	50–60
Ch; Edu;		
Soe; Oli;	Bri; Des;	Sig, U;
Mat; Gui;	Ele; Har;	Man; Geo;
Alex; Stav;	Fr; Kar;	Hil; Ti;
Tan; Dua;	Reja	Ja; Ger
Mar		

Using the same method described earlier when we determined the preference to talk of each individual participant or trainer inside of their language group, we can use to determine the likelihood of participants and trainers to talk in their own age group. We define p to be the total turn value for each participant or trainer of a specific age group and q and r as the total number of participants/trainers of a certain age group. We also set $\sum q$ being the total turn value for all participants or trainers talked to and n being the total number of participants and trainers in the whole course:

$$\frac{\sum p}{r-1} * \frac{n-1}{\sum q} * 100 \tag{9.2}$$

With these values we can then again determine the arithmetic means of all members of an age group, by adding these values for each age group and dividing by the number of members within the age group. The result is the following table:

Table 9.5 Likelihood of communicating inside one's own age group in [%]. Number of members is in brackets.

Age Group	30–40 (11) years old	40–50 (7) years old	50–60 (8) years old
Likelihood of communicating inside one's own age group [%]	129,86	100,99	113,19

This result shows aspects of *Homophily* within certain age groups. The age group of 30–40 years old in our course was a little more likely to communicate with members of the same age group.[6] The members aged between 40–50 were

[6]Which, with eleven members also happened to be the largest age group.

equally likely to talk with a member of their own age group. The members of the age group 50–60 years old were also a little more likely to talk to members of their own age group.
We can with a slight alteration in the formula also determine the communication processes from one age group to another:

$$\frac{\sum p}{r} * \frac{n-1}{\sum q} * 100 \tag{9.3}$$

We define p again to be the total turn value for each participant or trainer of a specific age group and r as the total number of participants/trainers of a certain age group. We also set $\sum q$ being the total turn value for all participants or trainers talked to and n being the total number of participants and trainers in the whole course. Proceeding to do so we can build a table of the likelihood of a speaker turn to be directed towards all the members of another age group in percent. If we use all the percentage values and sort them according to the age groups that the respective person belongs to, we can then calculate the means. This gives us the following table:[7]

Table 9.6 Likelihood of one age group communicating with another in [%]. Number of members is in brackets.

	To 30–40 (11)	To 40–50 (7)	To 50–60 (8)
From 30–40 (11)	129,86 %	119,06 %	46,00 %
From 40–50 (7)	114,52 %	100,99 %	79,29 %
From 50–60 (8)	80,75 %	117,06 %	113,19 %

We suggest the following hypotheses to in part explaining possibly relevant factors: We imagine the generation in the middle to share many topics with both – the elder as well as the younger generation. This allows the middle generation to easily be addressed by both younger and elder generations (see middle column in table 9.6). The middle generation itself however slightly prefers to speak with the younger generations (see middle row in table 9.6). Being in the middle of their career might motivate them to look for collaboration partners as well, which may make them less likely to approach colleagues at the end of their career path.

The communication preferences of the younger generation may possibly be explained by a similar tendency: Possibly the younger science teachers are eager to find partners for either professional collaboration or personal friendship,

[7] The results of table 9.5 have been added to table 9.6.

that are willing to invest time in either a working relationship or a friendship. This might make them lean towards peers of the same age (see top row in table 9.6). This pattern if confirmed by further research, may point to a generational communication gap, that in cases of courses with larger age disparities within a group may need to be proactively addressed.

The elder generation prefers to communicate with the middle-aged generation (see bottom row in table 9.6) yet also is more likely to communicate with age peers.

The role of the middle-aged group seemed to be rather important as a communication hub for both the younger and the elder generation. It seemed to be the only generation that was addressed more by both neighbouring generations. This information might be sensibly put to use in group assignments.

CHAPTER 10

RESULTS TO RESEARCH QUESTION 3: CONCLUSIONS FROM LITERATURE, TALIS AND FIELD STUDY

In this chapter we will discuss the results of research question 3. The results of the literature study and the analyses of TALIS have already been presented and in parts discussed in the previous chapters (see chapter 3 and chapter 4). Also, the results of the field study were presented to the reader (see chapter 8 and chapter 9). In this chapter we aim at drawing some broader principles from

- the literature study (for a complete overview see figure 7.10),
- the TALIS data,
- the field research on informal communication

that we believe to have a reasonable foundation in the research mentioned above. We admit that the foundation is a hypothetical one and that the principles we try to develop in this chapter are in much need of further research and require more empirical evidence to be gathered.

However, it is the aim and scope of this work to find some promising principles that according to the research above might turn out to be useful approaches for design and practice of science teacher trainings.

In the following sections we will discuss principles that we hypothesize to bear some practical relevance in conceptualising science teacher trainings. We believe that persons involved in the design of science teacher trainings may find the following hypotheses useful in order to reflect their practice. We also hope that the international community of PD researchers may find some of the hypotheses worthwhile to pursue in further empirical research.

10.1 Principles drawn from "Vocational personalities"

We believe that as already hinted at in subsection 3.1.2 (see pages 20ff.) it is very beneficial to reflect on the vocational personalities early on in the design process. Within the RIASEC typology Holland suggests the code Social, Artistic and Enterprising for the teaching profession in general [Abel, 1997, 2008; Eder, 2008; Foerster, 2008]. In case that Kaub's studies can claim validity for larger groups of in-service science teachers also: the typology for *science teachers* would most likely have to be described with the code for *Social, Investigative* and *Enterprising* (S-I-E).

We believe that the solid social component empirically found to be a strong part of a teacher's personality should be considered a core principle of design for every science teacher training course: If taken as such the science teacher training course could decide to put the social interaction of participants first and bring participants to interact, discuss or work on the content of the science teacher trainings. Time permitting, the maintainers of the course could either decide to increase the informal spaces inside of a training, and/or in case the time is too sparse, decide to resort to group- or pair work settings. In the case of international training settings the designers of the course should try to strengthen informal communication on the topics in order to make use of Granovetter's weak ties phenomenon (see subsection 3.6.1 on pages 49f.).

The teachers' disposition to talk about his or her **personal professional situation** (see pages 166f.) may also be transferred from the informal realms into the formal sessions of a science teacher training and thus in an integrated fashion help for the training content to become more associated with the science teachers' practice.

We also would like to introduce the idea that the social inclination of teachers might be regarded as the essential foundation for many future hybrid concepts of PD: Once a social network has been established or rather forged, the individual science teachers via their social embeddedness inside of a group might be brought to keep up a personal and professional relation that in case of international relations might prove to play a sustainable and vital role in the livelong, continual professional development of teachers (CPD).

The investigative trait is associated with observation, understanding and organizing [Oxf, 2011, p.132; Holland, 1997], which in terms of course design might translate into giving apt theoretical background regarding the course's content. Also presenting empirical evidence and statistics, that are proving the point the science teacher training tries to convey might help teachers with a strong investigative trait. Science teachers in their courses might react positively to analytic, scientific and problem-solving aspects playing a role in the course's underlying structure. We believe those teachers also to be susceptible to and benefitting from stimulated **Action Research** projects as described by Altrichter et al. [2008]. However, in case that further studies in opposition to Kaub's findings find the traditional S-A-E code to be dominant with in-service science teachers this approach might prove detrimental: teacher trainings reflecting the artistic instead of the investigative vocational traits might decide to abstain from too much theoretical background and replace it with the artistic teacher's preference for more open tasks allowing to deal with concrete material and the artistic disposition for creation. A possible design choice might include hands-on and role playing types of activities that play into the social as well as into the artistic domains.

While discussing Kaub's findings, we also want to underline his empirical findings, that science teachers themselves might not be homogeneous in terms of their vocational personalities, and that there might be a difference between teachers that studied science related subjects only and *mixed-type* teachers that studied one subject from the field of science and one subject out of the humanities – which in turn might influence design choices inside the course depending on the respective status of participants.

We believe the enterprising character traits also to be of some importance as a basic design principle. The natural inclination of the enterprising personality seems to *influence, lead* and *manipulate* to reach certain goals (see section 3.1). We hypothesize that this character trait might lend itself to addressing parts of the course's content in terms of discussions and side projects that might be pursued by individual groups of teachers. Teachers might feel drawn to create individual projects that bear a strong relation to the course's goals in terms of content and strategy. We assume this approach also to attend to artistic traits. Additionally, we believe that side projects may help science teachers to translate formalized knowledge into practical knowledge (see pages 38f.). In this fashion science teachers may test aspects of the course's contents more independently and begin to identify with related concepts.

10.2 Principles drawn from the Age structure of participants

As we have seen in tables 3.3 and 3.4 (see pages 24f.) the age structure of teachers currently is slowly decreasing in the age group of under 30 year olds as well as it is decreasing in the age group of 30 to 49 year olds. The age group of 50 years and older however is on a slow increase.

As shown by Richter et al. [2011, p. 121] (see figure 3.3 on page 30) preferences in certain types of PD are age dependent: The attendance in in-service trainings according to Richter are facing a steep decline in the age group between 50 and 60. Although the decline is somewhat content specific (see figure 3.4 on page 32), it basically shows the same decline for the most favoured course contents (e.g. subject content, subject-specific pedagogy, pedagogy and psychology and general skills). It has to be stated that the research by Richter et al. [2011] is based on data from Germany and replication of the study could help to verify the effects for more intercultural settings.

One conclusion to be drawn for PD in general is, that it may be advisable to devise different PD strategies for different age groups. While the age group 30 to 50 might be best served with a combination of in-service trainings and well fostered initiatives for teacher collaboration, the age group above 50 seems to prefer professional literature for PD (see figure 3.3 A, B and C).

For the design of a PD course this might mean, that the course maintainers might want to decide to implement different routes suited for different age groups. Further research is required to determine more age-related preferences and to find complementary PD strategies that increase the chance for successful science teacher PD across all ages. An idea that might be worth testing and that is currently rarely implemented[1] is for science teacher training courses to have digital as well as printed handbooks that may serve as

1. a sustainable tool for course participants to remember important aspects of their science teacher training,

2. as an extension of the training that may reach out older colleagues who stayed at home.[2]

The teachers' age is usually strongly correlated with years of his or her career experience (with the exception of career changers). This correlation is also reflected in Huberman's teacher career stage model (see figure 3.2 on page 26). For a PD course it may make sense to reflect the individual career stages already in the design stage of the teacher training courses:

While teachers in the first three years (Survival) might require more simplified or simplifying strategies for implementing certain PD related content and also

[1] Usually in larger, well-funded course designs.

[2] The CAT teacher training did produce a handbook [Welzel-Breuer et al., 2010c], obviously Richter's work had not yet been published by then [Richter et al., 2011].

might be interested in effective classroom management techniques, teachers in their 4–6th (Stabilization) year might best be served with best practice examples that invite imitation and experimentation.

Teachers in year 7–18 could be probed in order to determine whether they have moved more in the direction of experimentation or more in the direction of self-doubts. This information may be reflected in the trainers' approach towards the respective teachers, a teacher in the phase of reassessment and self-doubt according to Rolls and Helle [2009, p. 20] can be described by

> *"[...] varying degrees of self-doubt, ranging from a sense of stagnation, where teaching practice is felt to have become routine and uninspiring, to complete disillusionment brought about, for example by a perceived lack of career opportunities within the profession, or a series of educational reforms which the teacher is unable to align with his or her personal ideals and beliefs. As a result, the teacher may reassess his or her future career, attempting to regain previous commitment through a break with established routines; seeking pastures anew, inside or outside of the profession; or alternatively accepting the status quo and deciding to soldier on."*

According to Day [2007, p. 248], in the professional years 7–18 around a quarter of the teachers may suffer from detachment or loss of motivation. It is likely that science teacher trainings, that want to get their content to be picked up by teachers in different career stages, need to address teachers that are in a phase of *reassessment or self-doubt* differently compared to the majority of teachers that according to Huberman's model [Huberman, 1989] went into a phase of *experimentation and activism.* A differentiated treatment might in some cases consist of providing additional counselling sessions to teachers in the phase of reassessment or self-doubt in which the feeling is openly addressed and related to teacher training content relevant aspects of said phase. In other cases, it might be helpful to encourage the participants to open up to each other and invite conversations about the **personal professional situation** (see pages 166f.).

In the last phase, we see teachers that according to Huberman's career stage phases are withdrawing from the teaching profession in a phase called "disengagement" (see figure 3.2 on page 26). Our analyses on communication preferences with regards to age (see pages 222ff.) inside the CAT course revealed, that the 50–60 year old participants within the CAT course were most open to communicating with middle-aged teachers or with teachers in the same age group, while at the same not very often being addressed by young teachers (see table 9.6 on page 224). Also, the middle aged teachers did address the older teachers less. In case more empirical research supports these findings, it might in some cases be valuable to bring younger teachers in touch with older teachers in order to stimulate exchange of viewpoints on teacher training relevant content, especially when it is to be expected that both age groups might benefit (in terms of the teacher training content) from each other's views.

10.3 Principles drawn from the working hours of teachers and the issue of time

In this subsection we want to draw conclusions from three sections: In section 3.3 on page 34 we learned about the average time spent by science teachers throughout a typical work week. In section 4.3 we learned about teachers reporting time to be the number one (and number five) impediment preventing them from PD participation (see table 4.1). This description matches the data we saw in figure 4.4 (see page 69): According to the data, scheduled time for PD seems strongly correlated with participation rates. In subsection 4.4.1 on pages 82ff. we elaborated on the issue of *"Teacher training courses and time"* and reflected on the:

- scarcity of time for PD reported by teachers,
- the (possibly resulting) need for informal forms of learning "on the job" [see Heise, 2009, p. 11],
- the possible influences of the location of (science) teacher trainings on availability and flexibility of time and possible connections,
- the dispositions of teachers to strive for *Time Compatibility*,
- the problem of insufficient dedicated time creating a market for shorter and possibly less efficient teacher trainings as a European problem.

These paragraphs show, that time is a more complex issue, that might need to be addressed on different levels. The first level that a designer of science teacher trainings is confronted with is the educational policy of a country shaping the frameworks that PD is embedded in.

Political Dimension: Balancing between Education System parameters and PD Research

As a designer and/or maintainer of (science) teacher training courses it is necessary to determine the duration of the (science) teacher training course. The time for PD available to science teachers is largely defined by policies inside the educational system of a country. It is thus useful to adjust the (science) teacher training's length to the average number of days generally invested by the science teachers of the countries that are participating. A good starting point to determine a suitable duration is the table 4.8 on page 82. It also serves to be aware of the eventuality of larger discrepancies between countries in terms of time availability – sooner rather than later in the planning process. Additionally, the given percentage of science teachers engaging in teacher trainings in a specific country (also in table 4.8) will allow for an estimate of how many potential teachers might react to a call in the respective country. It may prove beneficial for any designer of science teacher trainings to extract those figures from the latest TALIS round.[3]

Since the average number of days spent in courses and workshops in a year is fluctuating quite strongly across the different countries, for international teacher training courses it is not advisable to rely on the mean values – yet possibly to either rely on the data provided by the country with the smallest average day spent on PD as reported in the latest TALIS or to orient oneself to a calculated mean value consisting of all countries that are addressed by the course call at hand. It is highly likely however that the number of courses attended per year also might vary with regards to the career stage, age or culture. For Europe the German study by Richter et al. [2011, p. 121] might provide some orientation (also see figure 3.3A on page 30).

According to the research by Timperley et al. [2007] and Yoon et al. [2007] (see section 4.4 on page 78), the duration of (science) teacher trainings or of PD concepts should encompass an extensive amount of hours[4] that according to Timperley et al. [2007, p. xxviii] should be spread over an extended amount of time,[5] while abiding to a certain frequency.[6] It is obvious that empirical PD research has a hard time determining an optimal duration for teacher training courses, for the same reason pointed out earlier and best summarized by Anne Sliwka:

"However, evaluating the impact of pedagogical preparation is made difficult by the fact that there is such a potentially wide range of different courses under this label, including courses in subject-specific teaching, and more generic courses in learning theory, educational psychology, sociology, assessment, measurement and testing, classroom management and so on. These courses are offered in

[3] The next TALIS round (2018) will publish first results in 2019.

[4] According to the findings of Yoon et al. [2007, p. 12] not less than 14 hours.

[5] According to Timperley et al. [2007, xxviii], in order to allow teachers to cope with PD content challenging their "existing beliefs, values and/or understandings".

[6] According to Timperley et al. [2007, xxviii], the frequency should be around at least every two weeks yet not less than once a month.

***different sequences** and with differing content and **intensity**.* [emphasis added] [McKenzie et al., 2005, p. 100]

Due to the diversity of subjects, concepts and methods it is also hard to make general statements with regards to the duration. According to the current state of PD research with regards to duration, it seems advisable (see section 4.4):

1. to aim for longer durations with the absolute minimum being 14 hours [cf. Yoon et al., 2007, p. 12],

2. to use an extended timeframe [Borko et al., 2010, p. 550; also see Darling-Hammond and McLaughlin, 2011; Hawley and Valli, 2000; Knapp, 2003], and/or develop hybrid concepts that escort and advise the science teacher trainings' content transfer into practice,

3. to keep the intervals between sessions shorter rather than longer. According to Timperley et al. [2007, p. xxviii] the currently most used interval being once every two weeks, sometimes less than this, rarely less than once a month.

School dimension: Balancing between science teacher's schedule and PD opportunities

With an average working week of 48,8 hours/week (see table 3.5 on page 34) lower secondary science teachers are facing an enormous workload. The fact that teachers report a conflict between participating in PD and their work schedule (see table 4.1 on page 65) is of vital importance for CPD. The scarcity of time leads Heise [2009, p. 11] to suggest developing: *"new ways of learning that can be implemented more informally on the job"*

Though Heise's judgement regarding the impediments to participation in traditional PD courses and workshops is absolutely correct, we believe that PD on the job is unlikely to replace (international) science teacher trainings, as stepping outside of one's local work environment according to Granovetter's ideas of weak ties [Granovetter, 1973] is essential for new impulses and also we are of the opinion, that dedicated time for reflection might actually require to give teachers a time off work and sometimes even to prevent daily routines from breaking focus and concentration to meet in conclave.

In good alignment with the views held by Borko et al. [2010]; Hargreaves [2000]; Heise [2009]; Stein et al. [1999] (see subsection 4.4.3 on pages 88ff.) we would like to suggest that the traditional forms of PD are in need to be complemented by the *"new ways of learning"* that can be exercised *"more informally on the job"*.

Looking at the average workload (see table 3.5 on page 34) we can try to identify items that may be suitable for new forms of PD. Obviously, the task demanding the most of the teachers' time is the item *Teaching* with 20,16 hours/week. It makes sense to try to create a more permanent feedback loop between science teacher training and the classroom practice.

An already proven ready-to-use concept that would allow for PD to connect to the teaching directly is the method of **Action Research** [Altrichter et al., 2008] that gives teachers the means to investigate their work, by means of smaller classroom related research projects, that can be implemented inside their practice. The international science teacher training could provide a number of suggestions for research projects and connect its participants as *critical friends*, who are willing to accompany each other.

In section 3.3 on pages 35ff. we already hinted at the potential that might be hidden in the item *Team work and dialogue with colleagues within the school* (see table 3.5 on page 34), which for science teachers amounted to 2,98 hours/week. and roughly tried to estimate the magnitude of the hours per year (see table 3.6). As previously mentioned TALIS 2008 results had found *"informal dialogues with peers on how to improve teaching"* [cf. OECD, 2009, p.57; OECD, 2010, Table 3.2; OECD, 2014b, p.103 Table 4.8] in case that PD could find a way of connecting to these weekly conversations between colleagues, this also might provide a beneficial available CPD gateway within school.

10.4 Principles drawn from the group dynamic reflections

We believe the theory of group dynamics presented in section 3.7 on pages 50ff. to be implicitly relevant for the field of PD. As international science teacher trainings often take place in foreign countries at least for some of the participants. It is important to be aware of the highly individual forms of self-esteem identity crises that the setting alone is capable of evoking within a science teacher, by placing him or her in the following situations:

- an unfamiliar setting,
- having to communicate in a foreign language,
- being more or less new to the topic of the training,
- being new to a group of strangers.

In accordance with group dynamic theories, we believe that the relation towards the group, as well as towards the trainers and towards the topic itself are of key importance to overcome the identity crises and to strengthen the new identity in terms of the group as well as the new identity in terms of the content.

This requires for the trainers inside a teacher training to be aware of the groups' internal structures. Knowing about and fostering the internal structure of the group allows the trainers to increase the flow of information within the teacher training course. According to group dynamic theory, the teacher training content is psychologically regarded as a threat to identity, especially if it presents alien concepts, that possibly are in opposition to the subjective theories unconsciously or consciously held by the individual. Fostering a group's cohesion, psychologically will strengthen his or her identity in the group, thus helping the individual to carefully open up to concepts that might be radically new.

In order to give the trainer an insight on the group structure, we suggest applying a sociometric test (also see subsection 7.2.2 on page 140ff.) as described by Stadler [2013b, p. 64ff.]:

1. The leader of the group or the group itself suggests a criterion[7] (e.g. "Who do I work with most productively?", "Who do I want to start a project with?", "Who would I like to interview?", "Who would I like to sit next to?");
2. The sociometric test can be determined only to have only positive votes or positive and negative votes;
3. The sociometric test can be determined to ask several criteria in one vote (e.g. "Who would you like to interview" and "Who do I want to start a project with?");
4. All members receive the same number of votes;
5. Votes are cast secretly with confidentiality assured (nobody knows who cast votes on who) or openly (voting's motivations can be discussed);[8]
6. Analysis of the results.

The analysis of the results can be done in a matrix (e.g. in Excel) which then can be turned into a sociogram (a visualized network) by using network visualization software (e.g. Gephi) that allows to understand the relations between participants and between participants and trainers. For the analysis Stadler and Kern [2010, p. 184] suggest the following questions:[9]

[7] Stadler and Kern [2010, p. 185] remark that the criterion should be use-oriented, socially and ethically acceptable. As sociometry's goal to increase group cohesion and productivity not cause the isolation of individual members.

[8] The implications of voting openly or secretly need to be reflected thoroughly.

[9] Author's translation.

1. Who voted for whom (positive elections); Who voted negatively for whom (negative elections)?
2. Who received how many votes?
3. Who received no votes?
4. Who voted each other?
5. Are there votes that are opposite?
6. How do votes differ with regard to different criteria?
7. Are the votes in alignment with one's own expectations?
8. Are there chains in the distribution of votes (A-B-C-D)?
9. Are there circles in the distribution of votes (A-B-C-A)?
10. Are there Stars in the distribution of votes (A-E, B-E, C-E, D-E)?

The results of the analysis give trainers (and if so decided the group) a powerful tool[10] to understand the underlying structure of the group and act upon it – such as to strengthen identity and cohesion and thus help the group to stabilize. By actively taking responsibility for the well-being of the group trainers can decrease resistance against radically new teacher training content and foster the participant's identity to a point that allows them to open up to new ideas and active experimentation.

There are many methods for a trainer to keep updated regarding the affective and emotional states of the group that serve as another basis for taking beneficial decisions with regards to the group and also communicate a sense of ownership (also see CET in subsection 5.3.1 on pages 100ff.). With a regularly conducted *barometer of opinions* the group is able to communicate relevant information to the trainers (e.g. state of concentration, state of emotion, agreement or disagreement regarding certain decisions etc.).

We believe that reflections on group dynamics should be considered a priority in the design stages of a (science) teacher training course.

[10] It is evident, that this tool must not be used without a deeper understanding of the psychological principles behind it and a thorough understanding of the effects the application of sociometric tests can have on the group. A group dynamic training is strongly advised as there is potential harm to the group in cases of incorrect application.

10.5 Principles drawn from sociological reflections

We believe the sociological dimensions described in section 3.5 on pages 39ff. are all pointing into the same direction from a practical point of view:

- **The self-contained classroom (SCC)**
  Lortie's sociological theory (see subsection 3.5.1 on page 40f.) has very large implications for CPD. In case that teachers in their beginning practice cannot fully align theory and practice and live through a *"reality shock"* that is causing an ambivalence *"towards the value and usefulness of theoretical knowledge"* [Bromme and Tillema, 1995, p. 261], they are unlikely to be persuaded by even a well-structured science teacher training course that fails to demonstrate its value in the practice.

  Furthermore, Lortie [2002, p. 77] describes a second obstacle (also see page 41): *"First, to be adopted a practice must be seen as consistent with the receiver's personality and "way of doing things." They portray the diffusion of classroom practices as passing through the screen of the teacher's self-concept – of the way he visualizes his peculiar style of work. [...] the teacher mediates between ideas and their use in terms of the kind of teacher he is."*

  This mediation process results in a very critical and personal assessment:

  The value of any collegial practice is unknown until the receiving teacher has tried it in the classroom and decided that "it works." The criterion of suitability to self is supplemented by a pragmatism of a highly personal sort. The practice must work "for me," and the teacher is the judge of what works.(ibid.)

  This leaves CPD with the full burden of proof: Until the science teacher training cannot show that the teacher training content "works" for each single participant it is unlikely to be adopted.

- **The autonomy-parity-pattern (APP)**
  The autonomy-parity-pattern (see subsection 3.5.2 on pages 41f.) attributes the teaching profession with a certain unwritten codex that permeates the working relationships. The expectations are that:

  1. No grown up should intervene in the lessons of a teacher.

2. Teachers should be seen and treated as equals.
3. Teachers should be courteous towards each other and not intervene into each other's business.

[Lortie, 1972, p. 42]

Altrichter and Eder [2004] in a survey (n=537) found expectations one and three to be prevalent in 65% of the surveyed teachers. The APP also has implications for CPD: The rule of not intervening into another teacher's business is likely to restrain open communication about practice. Although our analyses of the CAT communication revealed that the informal communication is dominated by talking about each other's **personal professional situation**, this is always done in a manner saving face. The APP might be another reason, why it is vital to foster group identity (see section 10.4).

- **Loose coupling**
  The traditional science teacher training itself has to be seen as a loosely coupled system from the system of the individual teacher and her/his class in the sense *"...that two systems either have few variables in common or share weak variables"* [Weick, 1976, p. 6]

  That is to say the typical western science teacher training does not see, reflect or interact on too many levels with the true classroom interactions that science teachers usually are engaged in – systemically it does not share many variables [11] with the system it tries to affect. If the number of shared variables between the teacher training and the classroom however were to be increased, this might also increase the level of coupling of the two systems and thus help to increase the effects of the science teacher training's content. Currently western science teacher trainings often are to be regarded as virtually independent in the following ways:

  1. Often for organizational reasons teacher training rarely takes place in the (or even "a") (school) setting the teachers regularly teach in and usually does not address school specific issues that would be relevant with regards to the training content.
  2. Due to a lack of time (see table 4.1 on page 65), the traditional training focusses on delivering the content in a nested and abbreviated sometimes theoretical form that often has yet to be translated into practice and in an untransformed form has some distance from the realities and conditions of practice.

[11] Or only very weak ones.

3. Usually the trainers are neither considered persons of trust for the teachers nor do they share any active variables but their common participation inside the training.
4. The science teacher training due to lack of time usually does not try to find out about the particular teaching styles or personalities of the participants. As a consequence, the necessary transformation of PD content into the applicable knowledge fit for the individual circumstances of practice and the practitioner is left to the teacher to figure out on his/her own.
5. Apart from a brief round of introductions the teachers are rarely brought into closer touch with each other. Despite empiric as well as sociological evidence showing colleagues to be a preferred source of information [Lortie, 2002, p. 77; cf. OECD, 2009, p.57; OECD, 2010, Table 3.2; OECD, 2014b, p.103 Table 4.8].
6. The teacher training often does not have the means to take care about the practical application of its content inside the teacher's classroom after the training – and thus misses the opportunity for sustainable change. Teacher thus face a risk of falling back into her or his routine.

Sociological reflections - Suggested vector of approach

The consequences for SCC, APP and loose coupling are somewhat facing in the same direction:

> *Unless the teachers are **convinced**, that the science teacher training content **is making a difference** in **their own classroom** and **is congruent with their way of doing things**, they are not likely to adopt the teacher training content into their practice.*

The implications for the design of science teacher trainings is less clear. We suggest trying to convince teachers by means of two strategies:

1. **Snippets of practice**
In an attempt to connect to the classroom practice, the maintainers of a science teacher training course should scan their training content for practical implications: These practical implications in turn should in communication and collaboration with the participants be transformed into practical "teaching snippets" that are together with every participant are custom tailored for testing in the participants' own practice. These "teaching snippets" can be accompanied by complementary **Action Research** projects (see [Altrichter

et al., 2008]) that help participants to learn about the effects. The teachers' experiences regarding the "teaching snippets" can be used in CPD sessions to slowly and in a controlled manner open up selected parts of the teachers' practice for discussion, thus carefully circumventing points one and three of the APP.

2. **Altering Perceived Locus Of Causality (PLOC)**
   This strategy builds on our experience described in subsection 5.3.1 on pages 100ff. and aims at actively trying to change the perceived locus of causality (see [Ryan and Deci, 1980, 1985]) of the science teacher training participants. Following Proposition III of the Cognitive Evaluation Theory (see page 102) we believe that science teacher training courses should try to move from a *"controlling"* communication and style that suggests an extrinsic PLOC to a more informational style that according to our understanding suggests treating the participants as autonomous individuals bringing in their own expertise. In this manner trainers and participants understand themselves as autonomous agents, that are teaming up to work on a common content (the science teacher training content). The trainers in this constructivist mindset would become information holders and co-thinkers, that also take care to grant the participants enough leeway to manoeuvre around the content by themselves and also encourage them to do so.

   The design of the science teacher training would reflect this approach by providing opportunities for exploring the science teacher training content in a very practical manner (e.g. visiting schools; testing material; planning lessons together and holding lessons). By designing a science teacher training with the intention of turning the participants into agents rather than recipients of the science teacher training might help them to develop an intrinsic PLOC.

Undesignedly, we find our suggestions to be in good alignment with the principles suggested by U.S. based research (see subsection 4.4.3 on page 88ff.).

10.6 Principles drawn from the field study

We deem our field study to be basic research, first and foremost helping to understand a little better the social and network related processes that occur inside an international science teacher training. We believe that gaining an inside perspective of science teachers informally exchanging in a face-to-face week in itself is a great opportunity of furthering our understanding of how teacher communities might work. Analysing the data did have the effect of guiding the literature research and also the data.

Caveat: *The following section is under the premise that the findings of the field study are to a certain degree describing causal relationships. Which we indeed believe to be the case. However, the causation as of yet cannot be proven the conclusions are to be handled with care.*

Still, having thoroughly investigated the informal communication processes of one science teacher training invites the question, what principles for the design could be drawn from the field study in this dissertation. Though we did investigate more than 26 hours of audio recording over the course of five days (see table 2.1 on page 10) resulting in 600 pages of transcript, we cannot claim to have any valid answer to this question. In our course we detected several correlations that we believe to be meaningful, but that due to the nature of the data we cannot prove to be in causal relation: In working with non-normally distributed descriptive data, we could not resort to parametric testing (see page 136). We were capable of devising a different way of testing for significance (see subsection 7.1.6 on pages 133ff.) for many parts of research question 1, that helped us to detect significant deviations in the development of topics over the week (see figures 8.5; 8.6) and highly significant and significant deviations over the daytimes (see figures 8.8, 8.10, 8.11, 8.12, 8.13, 8.14).

Under the premise, that the correlations described in chapter 8 on page 159ff. are to some degree causal in nature, we carefully suggest the following conclusions to be drawn:

- **Situational conversations**
  Informal conversations are influenced by the situation they occur in. We could see that programme as well as location and situation had a strong influence on the informal conversations at hand. Designing the programme schedule in a way that allows encounters with teaching practice, and possibly in a playful manner even arranging breaks (e.g. placing little science related toys or encouraging participants to tell each other personal profession related stories) in a manner that stimulates profession related or personal conversation, might encourage a deeper informal professional exchange and also might help the group to open up to each other, being able to discuss their own practice more easily (also see APP in subsection 3.5.2 on pages 41f. and in section 10.5 on pages 238ff.) when discussions on their practice are required.

- **The beginning**
  In figure 8.5 we saw that on the first day the informal conversations revolved around participants and trainers and around cultural aspects stronger than on any other day. Next to the programme schedule having an impact on these conversations, the data indicates a need to get to know each other and the setting more. It thus might be advisable to dedicate the time in the beginning to getting to know the setting as well as each other. Again, the designers of a teacher training course may decide to direct this by stimulating personal professional exchange.

- **Personal Professional Situation**
  The item description of this code reads:
  This subcategory deals with participants or trainers talking about their own professional career, about important aspects and/or experiences with their work and at their workplace. It also includes possible qualifications that they took in the past or plan to take in the future.

  Due to the code the dominating inside the field of profession related informal conversations, we believe that designers involved with PD concepts should think about using the personal professional situation either as a starting point for sessions inside science teacher trainings or as a reoccurring point of reflection of teacher training content discussed or imparted. We believe that this might help teachers to cognitively bridge the gap between *practical* and *formalized* knowledge.

- **The daytimes**
  In figures 8.8 and 8.26 we could determine two trends over the daytimes: We could see profession related conversations decrease over the day, while conversations over participants and trainers increased over the day. The profession related peak in the morning was largely due to conversations on the personal professional situation. It is not entirely clear, whether this trend is due to programme schedule or whether it might constitute a trend on its own. In case of the latter it could be beneficial to account for a slow decrease in concentration over the day and a growing need for social activities. We do not suggest taking this trend for too certain and advise further research.

- **Homophily**
  In our analyses of informal communication, we could detect **Homophily** [McPherson et al., 2001] with regards to nationality and age of Participants and trainers (see subsection 9.2.1 on pages 219ff.). We found that within CAT intralingual preferences correlated with the smallness of a language

group (see figure 9.20 on page 221). The implication being, that course trainers might decide to actively try to foster communication processes outside the participant's mother tongue, when the group of participants of the same mother tongue is smaller.
With regards to communication preferences of different age groups: 30–40; 40–50 and 50–60 we found a slight tendency within CAT course to preferably communicate with the next younger age group, leaving the age group 50–60 with being addressed a little less by other age groups and the age group 30–40 being addressed a little more (see table 9.6 on page 224). In cases where this tendency is found to be much stronger than in our case course maintainers might react to the communication gap between the age groups 30–40 and 50–60 by actively fostering communication processes between those age groups.

Chapter 11

Résumé and Outlook

11.1 Résumé

The effort

After gathering an unusually large amount of data (26 hours of audio) in order to take a unique *“behind the scenes”*-look on the informal communication processes inside an international science teacher training, we transcribed all of the audio resulting in 600 pages of transcript and inductively developed a code system in order for the data to be analysed. For the analysing process a lot of the data had to be manually queried in software MAXQDA multiple times in order to receive a complete dataset. Dealing with non-normally distributed datasets a new form of significance testing needed to be developed and applied.

In variation of the sociometric approach, we processed gathered communication data by applying a simplified communication model, in order to create sociograms. By means of the processed data we were able to detect by approximation conversations between individuals algorithmically. The resulting data was exported into network visualisation software and then described and finally in a second step analysed again in order to detect patterns.

After this the TALIS and literature studies commenced: With the TALIS 2008 (and later also the TALIS 2013) results, and the content of the transcribed informal conversations in mind, a substantial amount of papers, books and essays of quite a many related fields were read, in order to be on a par with current European and U.S. based PD research and to find research that was related to the results of TALIS and matched aspects that were addressed in the recorded conversations or had been observed in the CAT teacher training itself.

The results

The results offer a somewhat unique perspective inside the informal communicative preferences of science teachers, while inside an international science teacher training. It offers insight as to what degree teachers are reacting and are stimulated by external factors and allows for theories, of how communicative preferences might be picked up and integrated by international science teacher trainings. Furthermore, the study demonstrates the relevance of research from other scientific fields that bear a high relevance for the PD community and additionally draws practical conclusions for the design of PD. The dissertation opens new and different perspectives to the field by investigating sociological and psychological approaches.

11.2 Outlook

General problems of PD to be addressed

It is encouraging to see, what the young field of PD research in teaching has achieved so far. Empirical PD research has done its share of bringing the focus on the effects of PD on student achievement and also has been successful in determining factors that are very likely to influence student achievement (see section 4.4 on pages 78ff.). This dissertation itself tried to highlight several ideas for further research (e.g. pages 38ff.; 142f.; 241ff.). In this outlook I want to take a broader view on the issues I personally believe are ahead of PD research and need to be addressed: Despite growing efforts and remarkable progress PD still seems to suffer from current concepts and initiatives being *"... often fragmented, unrelated to teaching practice, and lacking in intensity and follow-up"* [McKenzie et al., 2005, p. 122].

Despite this diagnosis having been written 13 years ago, it still holds today, though a lot of progress has been made in PD research and a lot of university-based PD adopted the scientific achievements and integrated it in their trainings. The large majority of teacher trainings, suffer from the symptoms described above (also see figure 4.7 on page 85). This is probably due to two reasons, for one

"[...] the area of tension between university and practice-oriented needs of the schools is still in large parts lacking established organisational structures even if first approaches are starting to appear.[1]*"* [Sumfleth, 2017, p. 5]

and also

[1] Author's translation.

"there is such a potentially wide range of different courses under this label, including courses in subject-specific teaching, and more generic courses in learning theory, educational psychology, sociology, assessment, measurement and testing, classroom management and so on. These courses are offered in different sequences and with differing content and intensity." [McKenzie et al., 2005, p. 100]

For PD research these are somewhat hard conditions: It works hard to produce reliable results in a very heterogeneous field. Yet it lacks established organisational structures that allow it to make itself heard from all the different actors currently working in the field. Possibly parts of the problem are self-inflicted: Instead of addressing the actors directly and encouraging them to try different concepts in practice and then encourage them to share their results, organized PD research seems to try to avoid the intricacies of practice and remain scientifically respectable and untarnished.

I personally believe that PD research needs to actively seek the dialogue with all the different actors in the field and make itself heard, it needs to turn actors in the field into assistant scientist that provide data and expertise by collaborating with PD research. Quite possibly this may be the main problem as collaboration with PD would require PD to have *"established organisational structures"* [Sumfleth, 2017, p. 5].

PD research from within

Instead for PD research to merely collect data from selected PD programmes and accurately document its effects on student achievement, I believe that PD research should pursue a more active role in investigating the teachers' perspectives on PD. As of yet there is little research actually trying to find out, how the teacher behaves in PD or how the teacher experiences PD. Though we do not know whether this information by itself might be (ir-)relevant for student achievement, the information by itself might leave us with a better in-depth understanding of what is happening within PD. That information may help us to devise new concepts and ideas that may help the field to resolve the problems reported by science teachers. The *"rediscovery"* of sociometry provides a great opportunities to turn participants into research beacons that *report their position* with regards to a variety of factors, and help the trainer to take important decisions hopefully increasing acceptance and learning of teachers at the same time. I hope that this dissertation inspires the adoption of sociometry into the "toolkit" of PD research and practice.

Expanding sociological dimensions of PD

Sociology has done a lot for the understanding of the systems and mechanisms at play in the teaching workplace. I think it is vital to empirically check the sociological presuppositions and to try to open a dialogue between sociological research and empirical PD research. Understanding systems from within to me seems an important and exciting next step still lying ahead of effective PD research.

I hope that this dissertation serves as a gateway for further research to take a fresh and unconventional perspective on the complex problem that is PD, uniting the traditional with the new ...

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APPENDIX A

IMAGES

Due to the size of the relevant documents, a digital Appendix is required. We will give the a brief description of the files added to the digital Appendix in Appendix B. In Appendix A we will show landscaped versions sociograms from chapter 9. Please be aware that the Software *Gephi* changes colours with every newly generated network – so the colours for modularity classes can change between networks and relative networks even within the day.

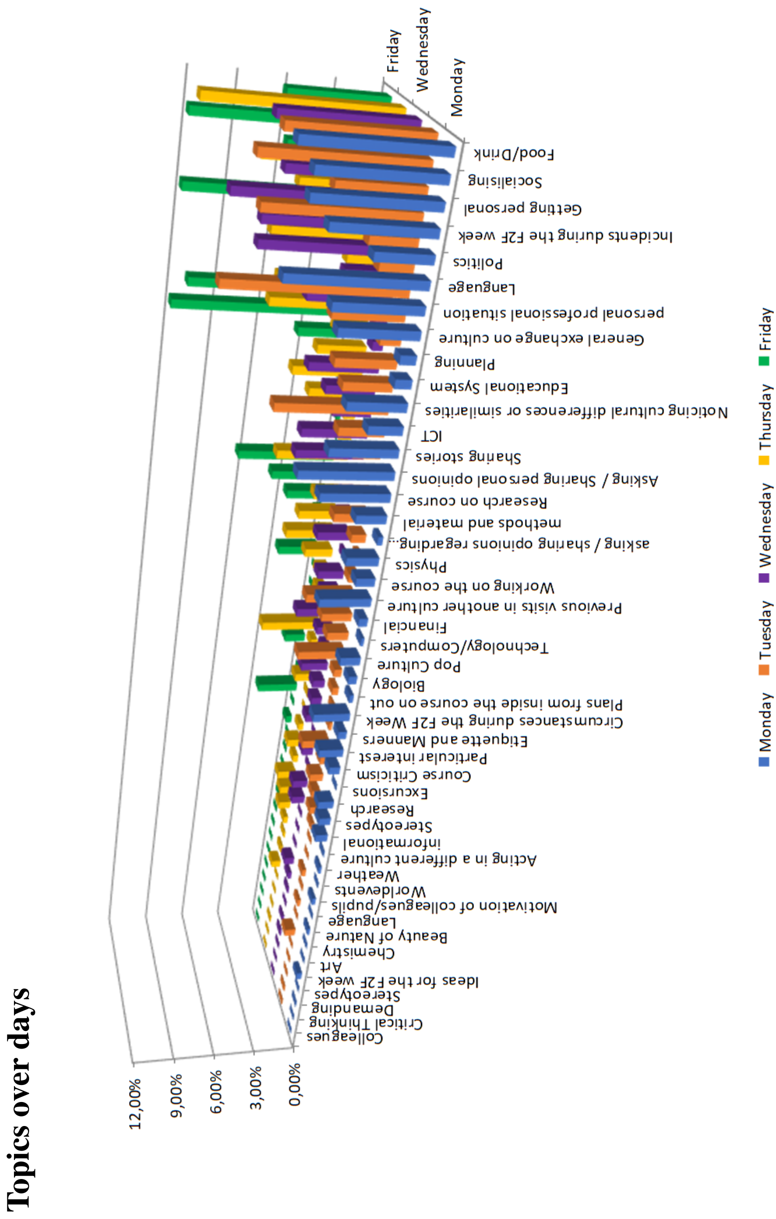

Figure A.1 Full data set: Development of Level-Two codes over the course of the week.

Whole week

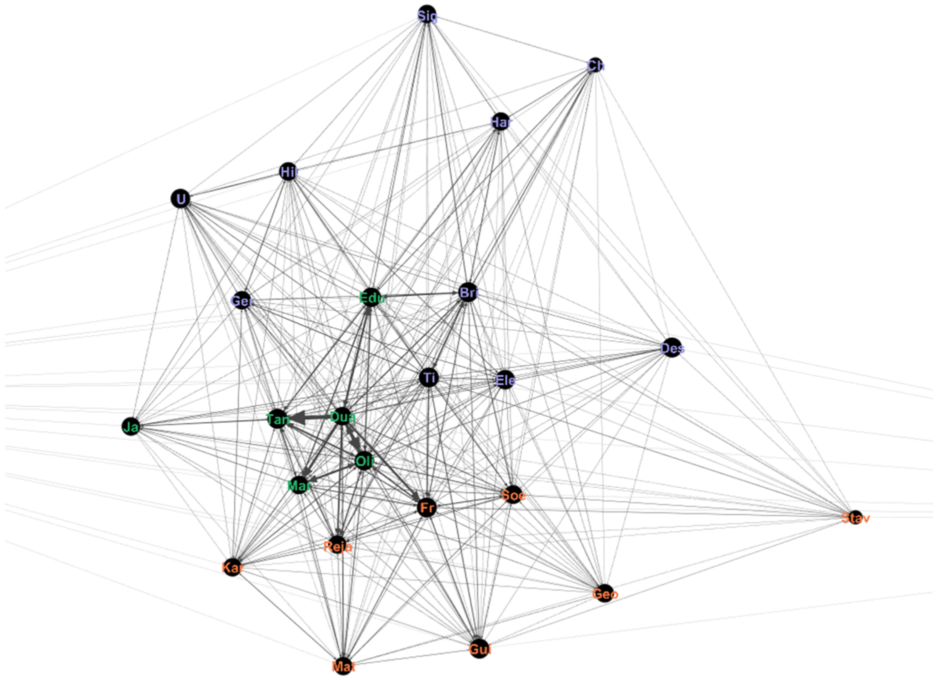

Figure A.2 Network relations over the whole week

Monday

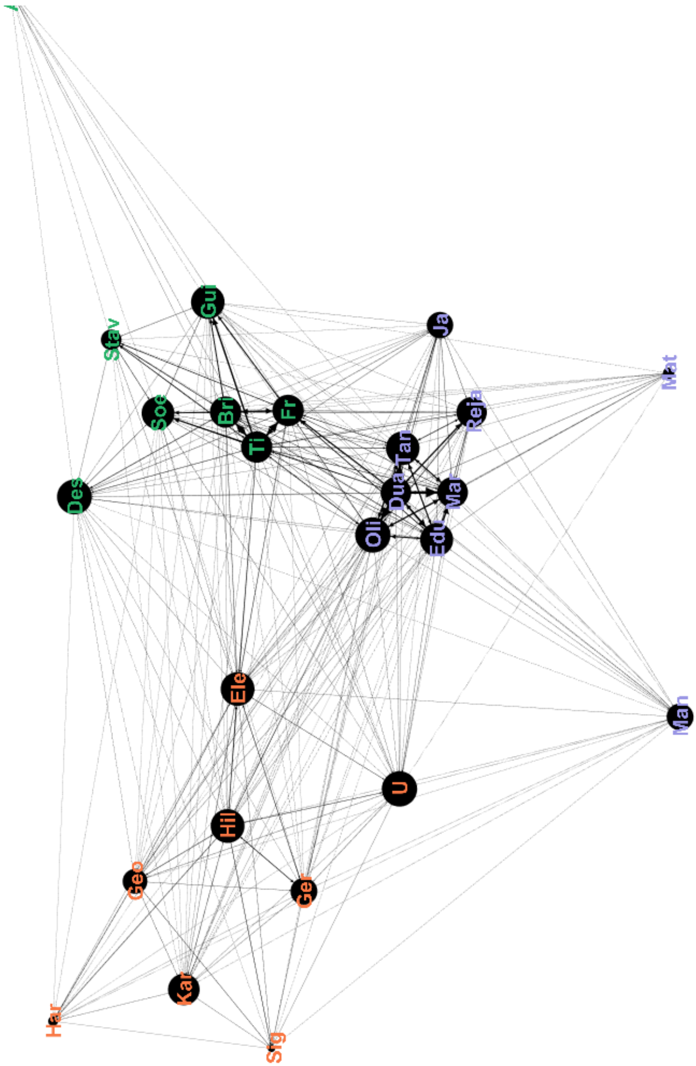

Figure A.3 Network relations on Monday

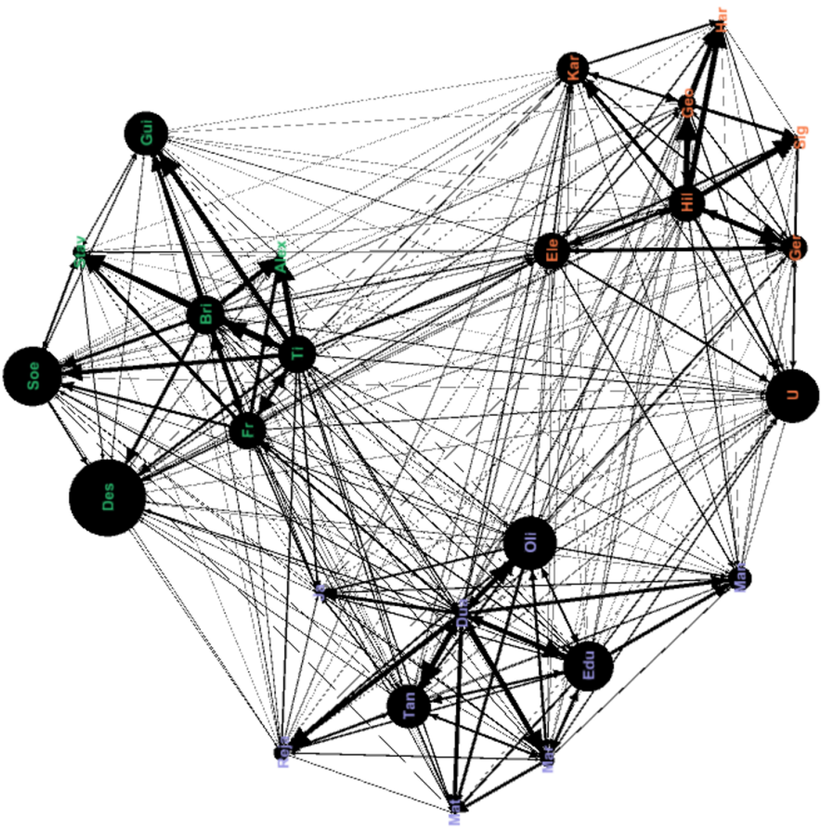

Figure A.4 Relative network relations on Monday

Tuesday

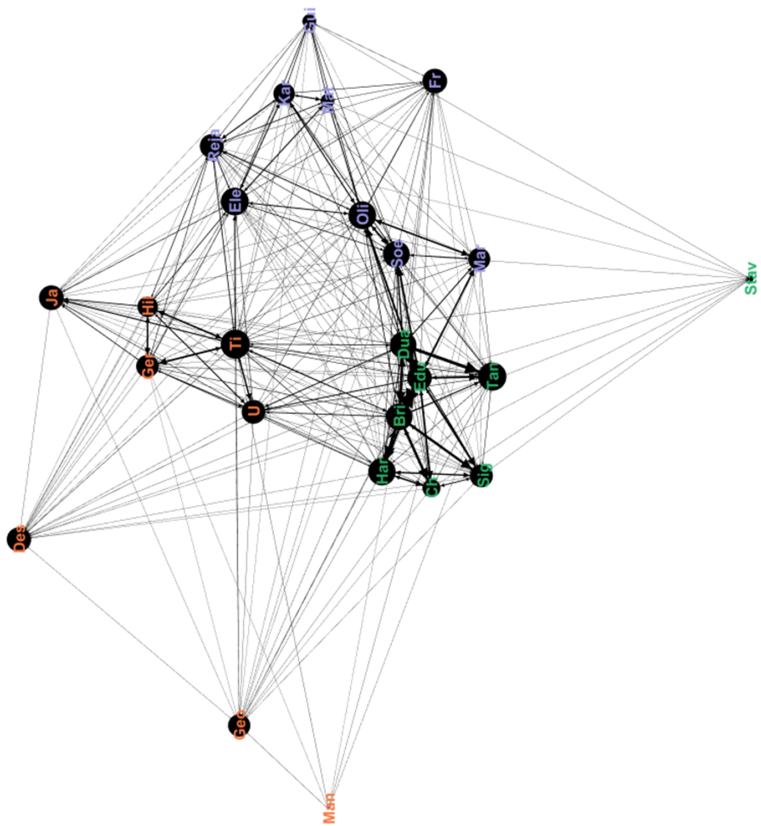

Figure A.5 Network relations on Tuesday

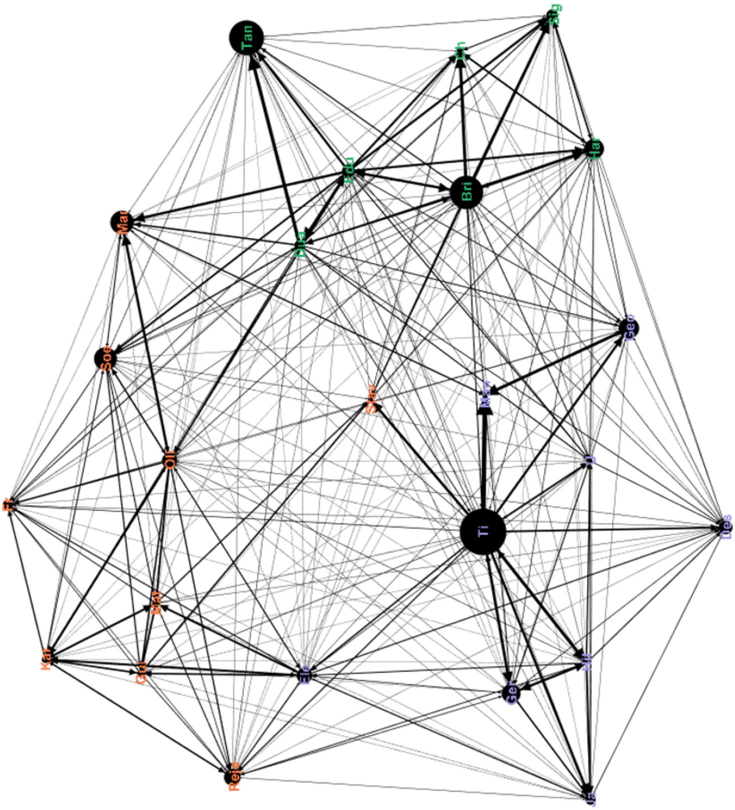

Figure A.6 Relative network relations on Tuesday

Wednesday

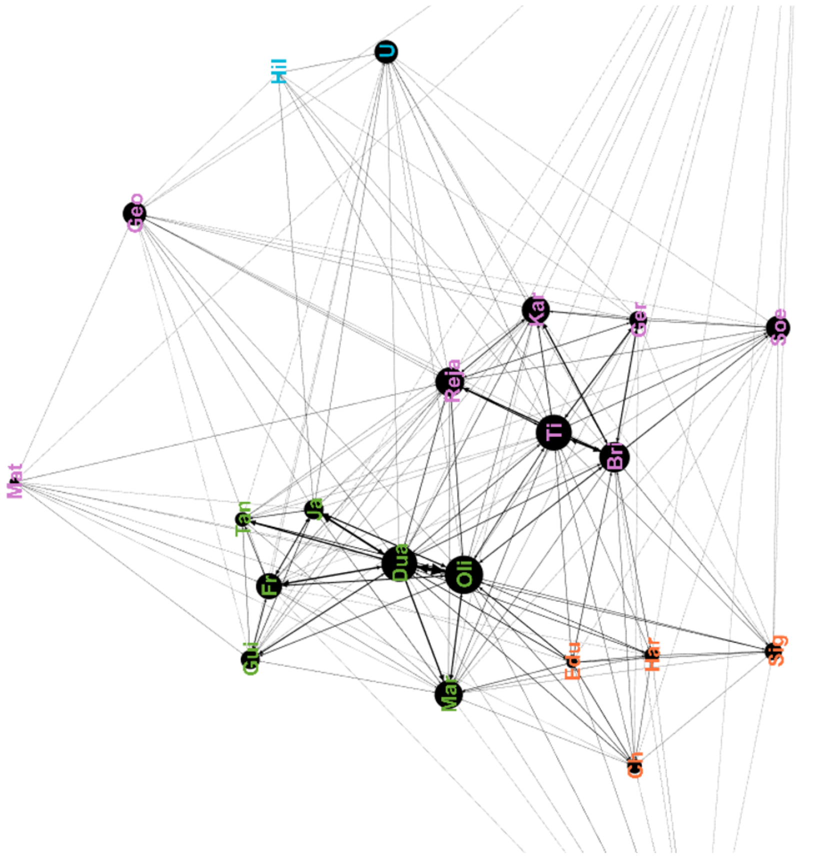

Figure A.7 Network relations on Wednesday

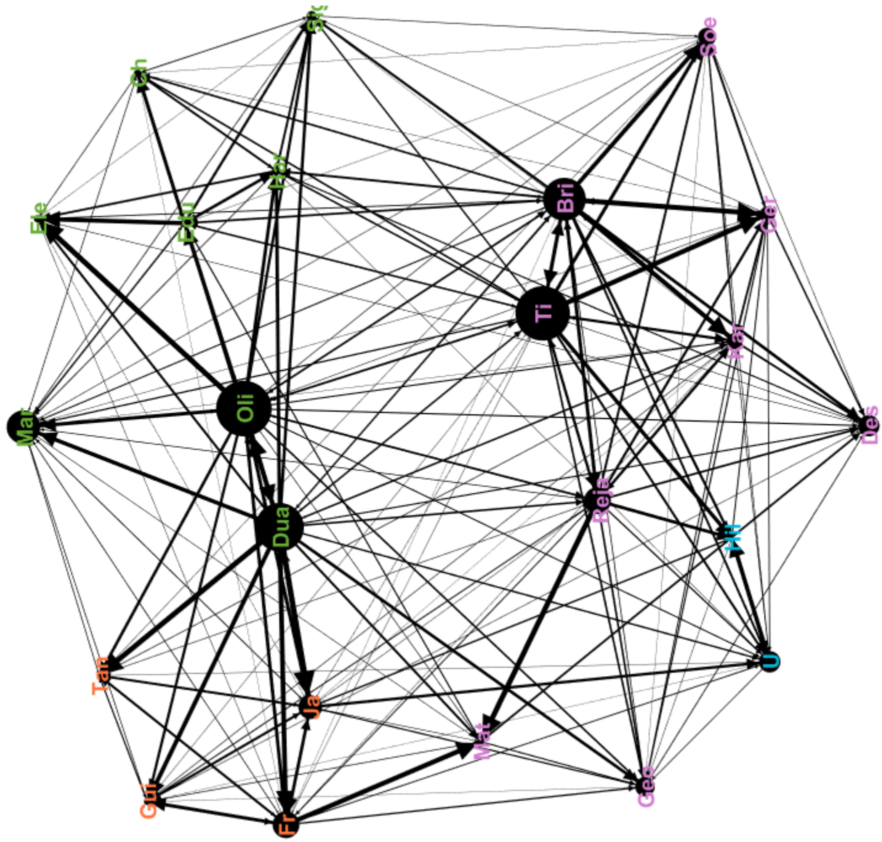

Figure A.8 Relative network relations on Wednesday

Thursday

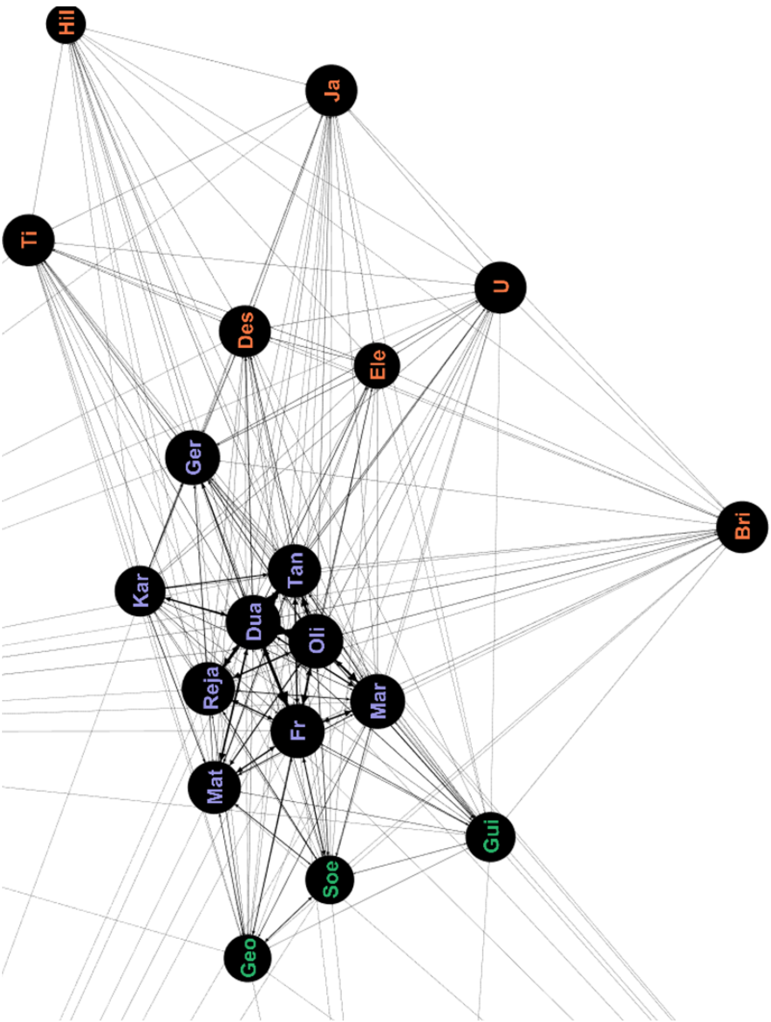

Figure A.9 Network relations on Thursday

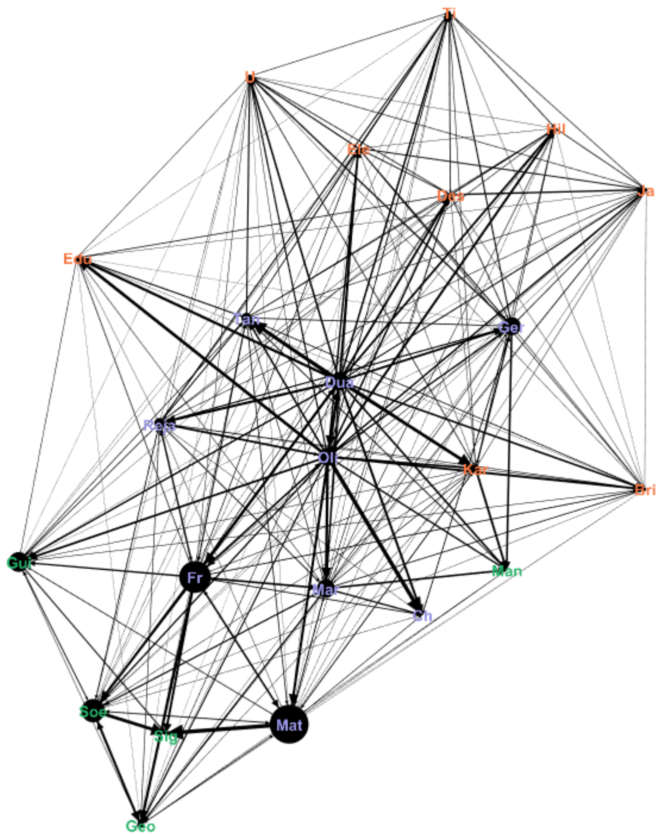

Figure A.10 Relative network relations on Thursday

Friday

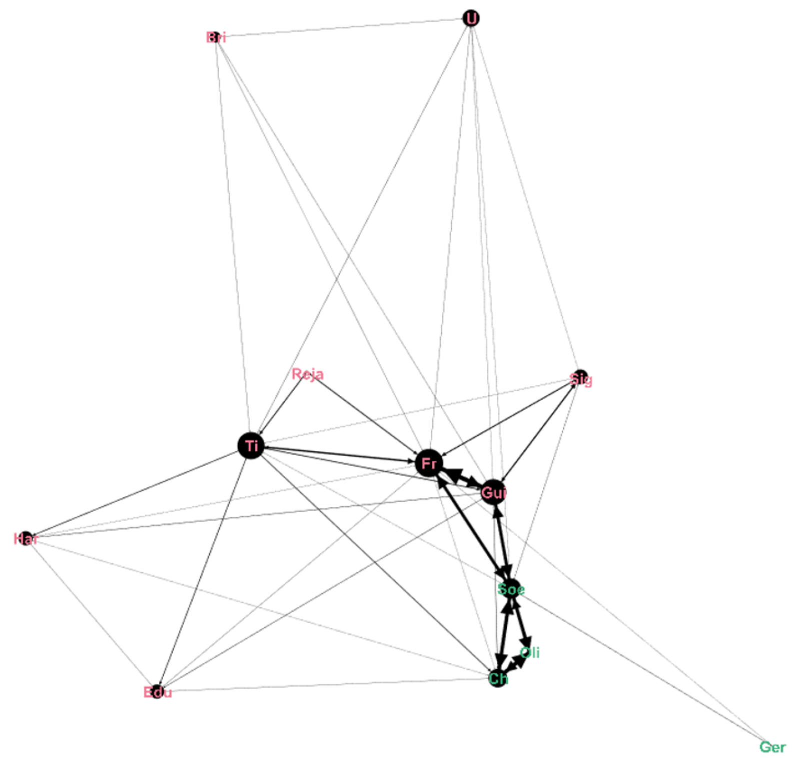

Figure A.11 Network relations on Friday

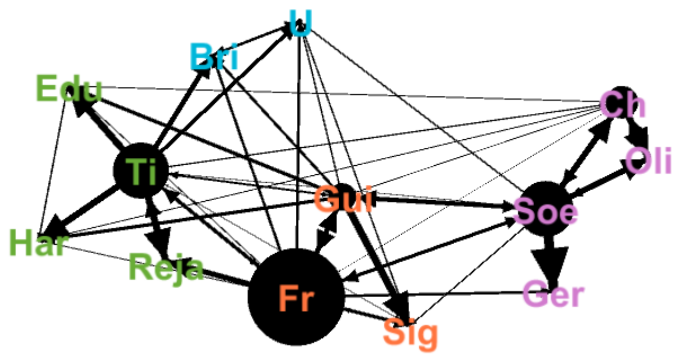

Figure A.12 Relative network relations on Friday

Appendix B

Digital Appendix

1. **Excel Based Analyses**

   (a) Person-Person-Speaker Turns
   The file contains Excel-Sheets with data extracted from the MAXQDA dataset. The file contains several matrices with speaker turns (see subsection 7.2.1 on page 137) from each participant/trainer to every other participant/trainer. Each day has its own matrix on a seperate sheet.

   (b) **Topics**
   This file contains the combined analyses regarding the coded topics. The analyses were conducted over:

      i. Time Week
         - Whole Week
         - Week Course
         - Monday
         - Tuesday
         - Wednesday
         - Thursday
         - Friday

      ii. Time of Day
         - Day Course
         - Whole Daytime
         - Morning
         - Afternoon

- Evening
- Late evening

iii. Location

- Conference Room
- Bar
- Hotel-Restaurant
- Restaurant
- Combined Restaurants
- Primary School
- Way Overview
- Way to Session from Hotel
- Way to Session from Lunch
- Way to All
- Wineyard

iv. Modularity Groups

- Cluster 1
- Cluster 2
- Cluster 3
- Clusters in comparison
- Before Lessons
- En Route by Car or Van
- En Route by Foot
- Before Session
- Session
- End of Session
- Welcome Dinner
- Farewell Dinner
- Lunch
- Breakfast

(c) **TALIS Science Teachers Sex and Age**
This file contains own database extractions with regards to Sex and Age of the TALIS 2008 and TALIS 2013 poulation.

2. **MAXQDA Files**

(a) **Intercoder Reliability Check**

- Intercoder agreement code specific results
  Contains the Topic codes listed according to their correlation with the intercoder partner. Also, an extracted version with codes that were deemed to be weaker is included. This contains results of the automated intercoder reliability check from MAXQDA 12 (12.3.5)
- Intercoder agreement results
  Contains the complete results of the automated intercoder reliability check in MAXQDA 12 (12.3.5).
- Kappa
  Contains the calculated Kappa of the automated intercoder reliability check in MAXQDA 12 (12.3.5).

(b) Patras Full Transcript
The MAXQDA File that was used to generate all analyses of the field research. The analyses were done using MAXQDA 12 (12.3.5)

(c) Patras Full Transcript.Intercoder
The file contains both codings from Coder 1 and Coder 2. And has been used to do the Intercoder Reliability Check.

3. **Transcriptions**

(a) Monday
Contains the transcriptions from Monday March 28, 2011

(b) Tuesday
Contains the transcriptions from Tuesday March 29, 2011

(c) Wednesday
Contains the transcriptions from Wednesday March 30, 2011

(d) Thursday
Contains the transcriptions from Thursday March 31, 2011

(e) Friday
Contains the transcriptions from Friday April 01, 2011

(f) Week
Contains the combined transcriptions gathered from Monday March 28, 2001 to Friday April 01, 2011.