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The Impact of the Teaching Process on the Quality of Teaching

DISSERTATION

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Dedicated to my parents, Ermira and Fehmi

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ABSTRACT

The assessment and improvement of the quality of teaching is an ongoing research topic. A recent study demonstrated that a better quality of teaching is achieved when the teaching process is evaluated. One model addresses the quality of teaching by considering the teaching process but is still limited in practices. To overcome this problem, in this thesis, a Teaching Maturity (TeaM) model is created. It is derived from general teaching strategies and recommendations and has been verified by university and school teachers who are also teaching informatics but not only. The TeaM model is evaluated with teachers at Universität Klagenfurt and teachers at some schools in Carinthia. The statistical results show the acceptance of the TeaM model by the university and school teachers, although limited to some practices. It raised the teachers' awareness to considered the teaching process as an influence on the teaching quality.

CONTENTS

1. INTRODUCTION

If you think education is expensive,
try ignorance.

Derek Bok

1.1 Motivation

Education is one backbone of society, and indeed, informatics is playing an important role, too. Nowadays, the influence of informatics on economics, art, medicine, and other fields is noticeable. It is a factor that reveals its significance in the market economy, and it is a boost for students and pupils to study informatics. Educators[1] do an excellent job, and they still want to make their classes funny and enjoyable. Consequently, comes the question: Are there other ways to improve informatics classes? One field of research, among others, is the quality of teaching and how to assess and improve it.

Not so long ago, the quality of a product and/or service was also a serious issue in Software Engineering in general. Looking for solutions, at the Software Engineering Institute (SEI) of the Carnegie Mellon University [FBS11], it turned out that the quality of a process has a considerable influence on the overall perceived and delivered product (service) [Ins]. Thus, SEI created a maturity model named Capability Maturity Model Integration (CMMI). Later on, among others, another maturity model for services (CMMI-services) was created. The term "maturity" is used in the context to define how mature a process might be. All variants of the above maturity models successfully assess the quality of the process by looking at the different practices that are used (and not used) during production or service delivery [FBS11]. When mapping these findings to the educational domain, one might wonder if there are ways to improve informatics classes by looking closer at the teaching process. Such an approach could help in further enhancing the level of teaching in our (informatics) classes.

Looking at the approaches to address the quality of teaching, the first to be mentioned are the traditional forms like student feedback, peer reviews, and inspectors in class. The results are all based on personal feedback, and they may be subjective

[1] In this thesis, the term educators refers to teachers.

depending on their unique feeling to the educators. There are no standards for such an assessment, and their absence opened this path of research. Researchers already presented some models within this scope. The models focus either on teachers' preparation, communication, engagement, or pupils/students, or course content or the environment [RB17].

On the other hand, some researchers were spurred by the concepts of CMMI [FBS11] and have created maturity models to assess and improve the curricula, institution, or course design either in the classroom environment or online [RB17]. These models so far focus only on some specific elements of teaching.

Unlike others, the work of Chen et al. [CCC14], [CMS+12] shows that indeed the quality of teaching can be influenced when managing the teaching process. They based their maturity model on CMMI's idea by assessing the teaching process for addressing the quality of teaching, but the model has some limitations. First, the practices were not built for school teachers (only for university teachers). Secondly, they conducted only an exploratory study, and finally, no empirical investigation was done so far for the developed model.

Considering the above situation, the thesis aims to improve our classes' quality by looking closer at teaching as a process. This means to decompose the teaching process into sub-processes and to define goals supporting these processes. This is done by presenting an understanding as well as an acceptable maturity model for teachers. This includes the definition (and verification) of best practices supporting the teaching process. Within this thesis's scope, an approach of constructing and evaluating a maturity model called the Teaching Maturity (TeaM) model, with the focus on the teaching process at the university, primary and secondary schools, is presented. In other words, the TeaM model is a collection of best practices derived from general teaching strategies and recommendations. It is also important to emphasize that in this thesis, quality refers to process quality, and for assessing it, the best practices are verified by teachers who teach at least two subjects, where one is for sure informatics.

1.2 Research Questions and Objectives

The shortcomings from the aforementioned models, in the way they manage the quality of teaching, opened a new path for research. It can be assumed that the quality of teaching is influenced by many factors, rather than just by teachers, pupils, textbooks, curricula etc. It is influenced by the teaching process as a whole. So, in order to improve the quality of teaching (in particular in informatics classes), this thesis aims at having a holistic view by addressing the quality of teaching in relation to the teaching process. In contrary to the other models in general and to the model of Chen et al. [CMS+12] in particular, this thesis' approach includes all levels of

educators. Considering such a situation, the main research question of this thesis is:

RQ How to assess and improve the quality of teaching in informatics at the university and schools in Carinthia?

The research question is followed by four sub-questions:

RQ1 How are the teaching process and the quality of teaching defined?

RQ2 What possibilities are there to assess the teaching process and the quality of teaching?

RQ3 To what extent is the quality of teaching influenced by the teaching process in informatics in schools and at the university in Carinthia?

RQ4 To what extent can a maturity model be used to improve the quality of teaching informatics at schools and university in Carinthia?

In correspondence to the aforementioned questions, the objectives are defined as follows:

- to assess the quality of teaching in informatics classes at the university and schools in Carinthia. This with the assumption that the management of the teaching process influences the quality of teaching.
- to define the terms of the teaching process and the quality of teaching with the assumption that explicitly defining the used terms yields to their better understanding.
- to find out and analyze the existing forms for assessing the teaching process and the quality of teaching, with the assumption that by exploring the existing assessment forms the lacks are derived.
- to assess the teaching process of informatics classes at schools and university in Carinthia, with the assumption that the management of the teaching process influence the quality of teaching.
- to build a model for assessing and improving the teaching process of informatics at schools and university in Carinthia, with the assumption that the management of the teaching process through this maturity model helps at improving the quality of teaching.

An evaluation with different studies is conducted for answering the thesis research questions and the results are shown in Chapter 4.

1.3 Methodology

A combination of methods is used for answering each of the research questions. When considering the first research question (RQ1), the definition of the teaching process and the quality of teaching is attained by conducting a literature survey. The information collection provided the first definition of these concepts, which some experienced informatics educators later on reviewed.

The literature survey is also used for answering the second research question (RQ2). A detailed review of related work aided in defining the fundamental approaches used for addressing the quality of teaching and the results showed that only one publication considers the teaching process (even though with limitations[CCC14]).

Source analysis and an empirical approach are conducted to define how the teaching process influences the quality of teaching in informatics in university and schools in Carinthia (RQ3).

A model, source analysis, and empirical approach are combined to define the extent to which a maturity model can improve teaching quality in informatics at university and schools in Carinthia (RQ4). For this scope, the Teaching Maturity (TeaM) model was created and used in different studies.

The collected information processing defines how to assess and improve the quality of teaching in informatics at university and schools in Carinthia (the main research question).

1.4 Structure of the Work

The content of the thesis is divided into five chapters. Chapter 2 provides the background information required to understand the basic concepts used during this research (in other words, to answer RQ1 and RQ2). So, a clear definition of the concepts *"Teaching Process"* and *"Quality of Teaching"* is to be found in chapter 2. Furthermore, a detailed overview of the related work is presented. It gives a current state of the related research going on so far in this field.

Chapter 3 presents the Teaching Maturity (TeaM) model created to address teaching quality by managing the teaching process. Because CMMI's concepts spurred the TeaM model, this chapter starts with a brief description of CMMI's works in the Software Engineering industry. Furthermore, it presents all the maturity models created for the educational domain based on the CMMI structure.

Four important components compose the TeaM model. The basic teaching activities are defined as *Process Areas - PAs*. The implementation of these PAs is dependent on the implementation of the *Generic Goals - GGs* and *Specific Goals - SGs*. The goals' implementation is achieved when the related *Generic Practices - GPs* and *Specific Practices - SPs* are fulfilled. All the implementations are addressed

in two forms: by continuous representation (*Capability Levels - CLs*), where only one PA is considered, and by stage representation (*Maturity Levels - MLs*), where a group of PAs is considered. A detailed explanation of how this all works is found in chapter 3.

The evaluation of the TeaM model itself is presented in chapter 4. There are different types of studies conducted, and all include various steps. As a pre-study, the definition of the terms used and an explicit presentation of the phases and subphases of the teaching process were established. In the follow-up step, a first draft of the TeaM was created, and in a study where educators were included, the best practices were collected. The next studies were focused on evaluating the TeaM model in practices with teachers at university and schools in Carinthia. In other terms, this chapter provides the results for RQ3 and RQ4.

A summary and conclusion of the work done in this thesis are presented in chapter 5. TeaM model, similarly to CMMI, will be an ongoing project for continuously optimizing the practices, goals, and Process Areas. So, this chapter mentions further work that has to be done.

2. BACKGROUND

> Quality is generally transparent when present,
> but easily recognized in its absence.
>
> Alan Gillies

From a literature survey, different models which address the quality of teaching are present. They try to extend the traditional ways like students' feedback, peer review and so on. However, their functionality is restricted to one or two teaching components. Nevertheless, there are results which show that the quality of teaching includes several components at once, and these components are included in the so called teaching process.

Eventually, the teaching process is related to the learning process [BC14]. Based on Biggs' definition, the learning process comprises the power factors (IQ), structural factors (working memory capacity), strategic factors (problem-solving), and affective factors(personal interest for learning). Creating a model to include both processes would require more extended research and study time frame. In the context of a Ph.D. thesis, the TeaM model was not thought to be at that level of detail. Hence only the teaching process was considered. However, some learning process attributes are incorporated in the TeaM model. For instance, the third phase (P3. Enactment) of the teaching process takes into account the delivery and consolidation and the assessment of the teaching units. Moreover, the second phase (P2. Preparation) includes the selections of methodologies teachers might use to better enhance the learning of their learners. In future work, it would be interesting to expand the TeaM model by considering the learning process too.

In this thesis, the assessment of the teaching process is relevant for addressing the quality of teaching. For that reason, the chapter provides a detailed definition of "Quality of Teaching", "Teaching Process", and the state of the art of the current related research.

2.1 The Teaching Process

Two basic concepts are used during the research: *Teaching Process* and *Quality of Teaching*. Building up the TeaM model means, firstly, defining what a teaching process is. Based on a literature survey [CND12], [Ign00] the components of the

teaching process are related with planning, revision, assessment and implementation. Planning refers to the process of setting goals on a scale level from the entire semester to daily goals. Revision is related to the pedagogical skills and to the cooperation between students learning and teachers' interest. For defining the level of effective learning outcomes of students, actively and regular assessments are needed. The assessment should include both students and teachers. Last but not least, the implementation of the plans, established during planning phase, is enacted. The implementation phase suggests to experiments also new ideas in practice.

Following the textbook of Meyer and Hilbert [Mey16] and considering the results of our literature survey [CND12], the teaching process was defined. The outcomes were further evaluated in a study explained in details in chapter 4, section 4.2. The teaching process now is composed of four phases (Fig. 2.1).

- *Initialization* – the phase where administrative issues of the teaching process are managed and defined;
- *Preparation* – the phase where teachers plan and prepare for the course;
- *Enactment* – the phase where the implementation of the teaching units takes place;
- *Quality and Incident Control* – the phase where possible incidents and the teaching process itself are observed, analyzed and refined.

These phases have then further been split into sub-processes representing the Process Areas of our model. After some revisions and considering all the feedback collected, it ended up with 12 PAs that are also depicted in Fig. 2.1 as Process Areas P1.1 up to P4.3.

P1.1 Determining Commitment (DCOM)- the responsibilities of all relevant stakeholders are defined and agreed upon/confirmed.

P1.2 Availability of Resources (AR)- the necessary and given environment and the infrastructure are dealt with.

P1.3 Discovering Needs (DN)- the requests from all the stakeholders are organized.

P2.1 Design Objectives (DO)- the course aims are defined.

P2.2 Content Planning (CP)- the information that has to be transmitted to the pupils/students is generated.

P2.3 Methodology Selection (MS)- teachers define the methods to be used for transmitting the information to pupils/students.

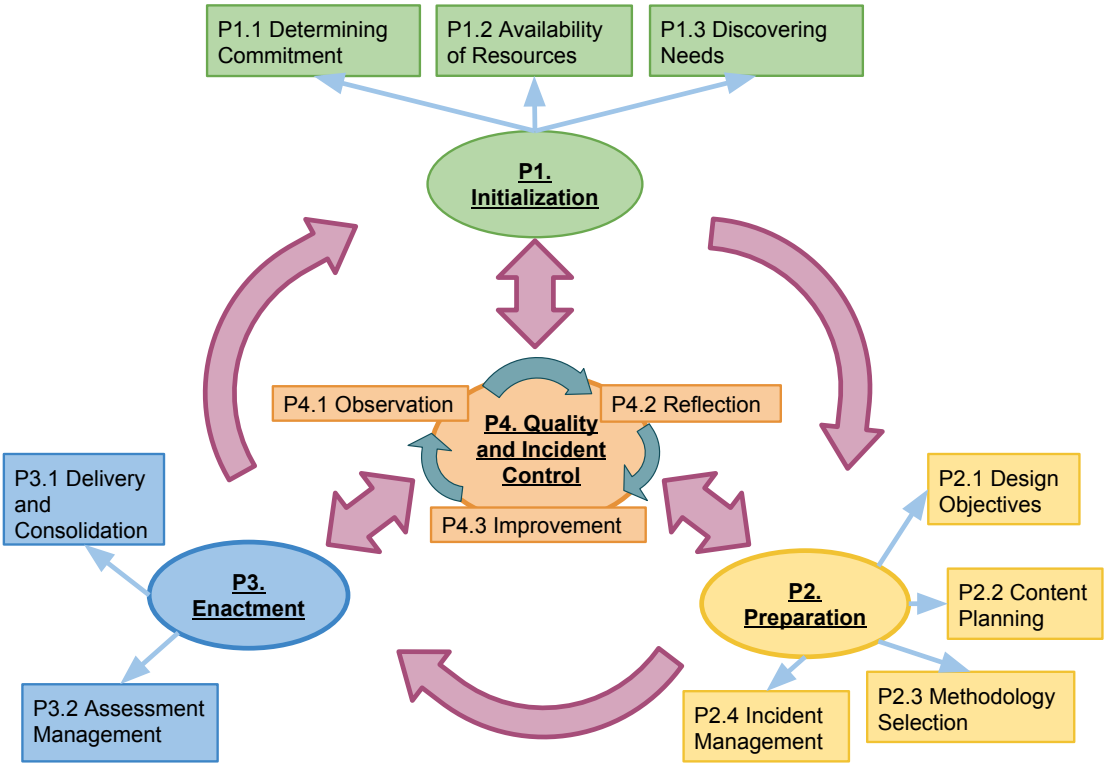

Fig. 2.1: The graphical representation of the teaching process as defined for the TeaM model [RB17].

P2.4 Incident Management (IM)- incidents are foreseen and corrective plans are established.

P3.1 Delivery and Consolidation (DC)- teachers conduct their teaching units.

P3.2 Assessment Management (AM)- learning outcomes are evaluated.

P4.1 Observing the Teaching Process (OTP)- the other phases are assessed and measured.

P4.2 Reflecting on the Teaching Process (RTP)- the outcomes from the monitoring process are analyzed and corrective actions are derived.

P4.3 Improving Teaching (IMT)- corrective actions are implemented.

These Process Areas (column one in Figure 2.2) were used as a basis to create the TeaM model. Firstly, it was examined which of these PAs are contained in CMMI,

and secondly, which are or are not included in the model of Chen et al. [CCC14]. The comparison shows that the missing areas of the model of Chen et al. can be discerned immediately as well – especially the selection of the teaching methodology, the reflection and the course delivery step is of importance, but it is not handled there. More information is to be found in Section 3.2.1.

TeaM PAs	CMMI PAs	T-CMM (Chen) PAs
P1.1 Determining Commitment (DCOM)	SD, STSM	
P1.2 Availability of Resources (AR)	SSD, CAM	CMC (SG 2)
P1.3 Discovering Needs (DN)	(REQM)*SSD	Course req.dev(CRD)
P2.1 Design Objectives (DO)	QWM, WP, WP	Course & Teaching P.(CTP), QCM
P2.2 Content Planning (CP)		CTP, CM, ICTM
P2.3 Methodology Selection (MS)		
P2.4 Incident Management (IM)	RSKM, SCON	CTP
P3.1 Delivery and Consolidation (DC)	REQM	
P3.2 Assessment Management (AM)	MA	Learn. Verif. & Teach. Val. (VAL)
P4.1 Observing the Teaching Process (OTP)	PPQA (based on commitments) WMC MA DAR MA	Course M & C (CMC)
P4.2 Reflecting on the Teaching Process (RTP)	IRP, CAR, CM, DAR	
P4.3 Improving Teaching (IMT)	OT, OPF	Teach.Proc. Focus (TPF) Teaching Innovation (TIA)

Fig. 2.2: Process Areas of the TeaM model (first column). The table also presents the differences and commonalities between the TeaM, the CMMI [FBS11] (second column) and the T-CMM [CCC14] (third column) models.

2.2 The Quality of Teaching

Providing an agreed definition of quality is impossible because different definitions exist under different contexts [Els12]. Elshaer did an in-depth review for this issue and defined that a universal definition of quality is to be found on the world's largest developer and publisher of international standards ISO 9000 [Def00]. There, the quality is defined as:

> "Degree to which a set of inherent characteristics fulfills requirements" ([Def00], p.7).

Inherent is used in the sense of existing in something seen as a permanent characteristic. At the same time, requirements are defined as needs generally implied. Moreover, generally implied refers to customers and other interested parties. Although this definition is widely used, few authors consider this definition, not reliable [Els12].

Similarly, when focusing on the educational context, it is difficult to clearly define the quality. Since the TeaM model does not consider the learning process, only the quality of teaching is investigated. People have their definition of the term "quality", and that might be diverse. The same also holds in the educational context [HG93], [HLR08]. Different researchers in this domain propose various teaching elements when addressing the quality of teaching. In this thesis, "teaching elements" refers to all resources required to successfully transfer knowledge, like teachers, students, and materials. The researchers' major part refers to teachers' and students' learning outcomes as basic elements to indicate the quality of teaching.

According to Harvey and Green,

> "Quality can be viewed as exception, as perfection, as fitness for purpose, as value for money and as transformative" ([HG93], p.9).

How well does this definition fit in the educational domain? When the definition of quality is generally considered as personal, are there objective criteria for defining what "good teaching" is?

Defining such criteria is difficult due to different reasons. First of all, the teaching element's effectiveness always depends on other teaching elements that might be present or not. Secondly, teaching elements are general elements that can be observed in different behaviors, but often in different ways [HHL+10]. Finally, the teaching element's effectiveness is a result of comparison between classes and teachers, and therefore, statements of quality are relative to other classes and teachers.

Literature suggests that the quality of teaching makes a significant difference in learning at schools and that schoolchildren must have "highly qualified teachers" [CS03]. In an article from the United Nations Children's Fund [UNI00], high-quality education should include learners, environments, content, processes, and outcomes. Based on this, learners should be healthy, devoted to participating in learning and supported by their family and society. The environment should be adequate for boys and girls. It should provide the necessary resources and should be safe and protective. Content should be relevant in curricula and teaching materials. This includes basic educational knowledge and knowledge in life like health, nutrition, and so on. The processes refer to student - centered approach and well management of the classroom. Last but not least, outcomes incorporate knowledge, skills, and attitudes.

Coe et al. [CAHM14] suggest the combination of these elements as a reference to good quality of teaching: content knowledge (teachers having knowledge of the subject they teach), quality of instruction (questioning and assessment as evidence of the quality of students outcomes), classroom climate (interaction students - teachers), classroom management (management of classroom resources and space), teacher beliefs (the practices they use to achieve the proposed aims and their theories for better teaching) and professional behaviors (reflection and further professional development).

In a study conducted by Smith, designing learning activities that inspired pupils' interest and enthusiasm are basic factors of the quality of teaching. Less importance is given to the attitude and to the understanding of the subject [CS03].

In most findings of the literature review, teachers are considered as the basic element that influences the quality of teaching [LX09], [CS03], [HLR08]. So, in the study by Smith, he states that highly qualified teachers have full state certification or pass scores on state teacher exams [CS03].

In the context of university teaching, other literature refers to "good teachers" as those who have the experience, are organized and expressive [HLR08]. On the other hand, "Excellent teachers" have a passion for learning and teaching their learners.

However, a definition that all agree upon is that good teaching leads to the learners [CAHM14].

Considering the above general description about quality, in this thesis, **the term quality refers to the process quality**, and its definition is given below.

Definition of teaching quality. *The term quality of teaching is defined as a term that has the below functionalities:*

(a) adhere to the state of the art of teaching

(b) enable learners to acquire competences easily

(c) ensure that learners are satisfied with the courses

The first functionality represents the activities (practices) that teachers apply during their teaching process. The second functionality addresses the efficiency if the teaching process enable learners to obtain the knowledge. Finally, the satisfaction of the learners is considered as well.

Firstly, the TeaM model's evaluation is done by comparing the teachers' performance (through the TeaM model) with the learners' feedback. The learners' questionnaires were established by experts in the field of building surveys, and they assess the quality of the course considering the attributes "easy" and "satisfaction." This is one reason why in this thesis, the definition of quality is addressed in respect to functionalities *(b)* and *(c)*.

Secondly, the definition of quality was also related to the cognitive load and satisfaction theory. The process of considering teaching and learning should be international, strategic, and effective. For these purposes helps the cognitive load and satisfaction theory [Swe11]. Based on this theory, working memory is where the new relevant information is put either for processing or deleting. When processing, then the new information is loaded into the long-term memory. This theory shows that effective learning is achieved when the working memory is not over-whelm [Swe11]. One of the three types of cognitive load is the Extrinsic Cognitive Load, to reduce the cognitive load by using graphical or multimedia elements when enacting the new teaching content. For that reason, state of the art is considered in the definition of the quality of teaching. The methodology is also relevant, referring to the above theory. Thus the teacher should judge the to use or not mixed ways of teaching. The two other types of Cognitive Load, Intrinsic and Germane, are also important when evaluating teaching and learning. A lot of models covering both processes are produced. One very known is the Visible Learning from Hattie. It is a performance indicator when evaluating teaching and learning. But, since the TeaM model focus only on teaching, similar approaches are to be considered in future work where the expansion of the TeaM model, including the learning process, is planned. Therefore, the below section discusses the related work about models which only address the quality of teaching.

2.3 Related Work

The improvement of teaching is closely related with the assessment of its process quality. The traditional forms for addressing the quality of teaching by giving personal feedback like students feedback [KLK02], peer evaluation, inspector in class [CAHM14], are seen as quite subjective [oPoM99]. The lack of standards to address the quality opened a path for research in such direction. Here, a lot of authors address the quality of teaching by mainly focusing either on teachers (preparation, communication, engagement), pupils/students, course content, or the environment. Taking a closer look at the existing work, we can divide these models into several groups.

There are models that, for addressing the quality of teaching, focus only on teachers, and their results reveal the lesson learned by the teachers. One well-known model is the AQRT model. It addresses the quality of teaching by assessing the teachers' teaching practices [CMS+12]. Four teaching practices were considered: task design, task presentation, class management and instructional response. There, the authors applied the model in thirty physical education lessons with nine elementary teachers in physics. Each lesson was taped and validated through the AQTR model. The results emphasize that teachers mostly implement the task for

presentation and partially provides quality for students' engagement. Furthermore, the results show different quality levels among teachers. All in all, we can state that the model is applicable although restricted only to teachers.

Teaching quality evaluation is a system proposed by Lu and Xue [LX09]. It concentrates on university and colleges teachers as the most important element for addressing the quality. The system helps in collecting data about the teaching tasks of the teachers and on their analysis. The results allow the administration department to know the current situation of teaching and to propose better teaching tasks for teachers. It motivates for more scientific research activity to further increase the title of teachers and to improve the teaching quality.

The competence based model is another model that assesses the teaching quality through teacher - licensure tests [Meh90]. Mehrens' study is more an investigation and analysis of licensure and teachers competency tests. The teacher - licensure test operates more as a basic to ensure that teachers have a minimal level of competences (knowledge and relevant professional skills). It does not ensure the elimination of the shortcomings from the educational sector or the ineffectiveness of the teachers. The model still relies on teachers level for addressing the quality of teaching.

The Standing Conference of the Ministers of Education and Cultural Affairs of the Countries in the Federal Republic of Germany proposed a similar model named the "Competence based model for teachers" [Sek04]. The model defines how to teach and the assessment is based on these competences. It offers some standards for teachers training. The standards include the following competences: teaching (with the meaning that teachers should be experts in teaching and learning), education (teachers have fulfilled their educational tasks), assessment (teachers fulfilled their assessment tasks responsibly) and innovation (periodically teachers' development skills).

TEQAS is another model where quality is addressed by assessing the education of teachers [Dil07]. Dilshad showed the applicability of the model by covering five quality variables: quality of learners, quality of learning environments, quality of content, quality of processes and quality of outcomes. The study was conducted through interviews (questionnaire) with 350 students in bachelor and master education programs. It involved students and teachers from three government colleges for elementary teaching and four education departments in university of Bahawalpur. The results show a low quality of qualified teachers, low content provided to students, not appropriate learning environment and low outcomes and processes. What was noted, was the good quality of learners. Beyond the assessment, TEQAS model offered recommendation for improvement. In such a study, the model suggested the revision of the curricula, the updates of the academic resources, student - centered approach and faculty development.

Members of EduQTech, a Spanish research group, defined a Code of Good Teaching Practices based on quality criteria [MPA+08]. The international standards for

quality are used as reference model and the quality concept is applied in the daily teaching activity in university. The Code of Good Practices was built as a mixed model of elaboration of some quality standards from different countries. The standards of quality used in this research were in a form of peer review on degree programs and/or research programs. The results show that the university teachers involved in the project are more motivated in their educational research and activities. After some years Code of Good Practices was supported by a Web tool. The aim was to include the quality and innovation concepts in a daily teaching activity [IPI+14]. Such a platform helps teachers to share their learning resources among them, and to improve and standardize them. Even here quality is addressed by considering only teachers, and partially, the curriculum.

Furthermore, there is the TALIS model which assesses the quality based on working condition of teachers and the learning environment [OEC61]. The components of the model are grouped in terms of policy. Five main policy are to be mentioned: attracting teachers to the profession, developing teachers with the profession, retaining teachers in the profession, schools policies and effectiveness, quality teachers and teaching. The OECD article is a technical report where they applied the model in a pilot test with five volunteering countries: Brazil, Malaysia, Norway, Portugal and Slovenia. There are four research areas: school leadership, professional development, teachers appraisal and feedback, and taching practices and attitudes. Two types of questionnaires are used to collect and analyse the data. One is for school principals and one for teachers. According to the results of the first pilot test, the model was successful and helpful for teachers.

There are other approaches that consider the pupils/students and the teachers' interactions for addressing the quality. However, some of them fail in demonstrating any practical effect. The CEM model is one example. It assesses teacher quality based on students' outcomes [AK14]. Azam and Kingdon applied their model to compare the students' results of the exams from the tenth-grade to the twelfth-grade. They evaluated the progress of children in the same subject for two years, and teachers teaching the same subject in multiple class over the years. Based on the results (that might have improved or not) the teacher's contribution was estimated. Something noted in the study stated that teachers' characteristics do not relate to the teaching effectiveness.

Another model is that of a standard-based learning and assessment system of the National Education Association [Nat11]. It shows how student learning standards can be connected with teacher education and assessment. Although there is no concrete implementation in practice, they are suggesting to use the system to measure the quality of teaching.

The assessment of teacher competencies and students learning and feelings is another model presented by Snook et al. [SOB+13]. In their model, six alternative policies are offered. When implementing them in details and with the required

resources, than the effectiveness of the schools is increased. The policies are demanded for extending the teaching materials, developing management, appraisal and professional skills, for collaboration between schools leaders and teachers, and for educational research. The educational research is considered as useful for improving teaching and learning [SOB+13]. In their article, Snook et al. investigate the school system in New Zealand. Incentives and sanctions are recommended to be used as stated by the gains or losses in students' achievements. The study emphasizes that teachers are not the only factor which influence the quality of teaching, however they are important in improving school effectiveness.

The "Angebots-Nutzungs Modell" is a model used to address teaching quality based on teacher-student interaction (results, feelings, and environment) [HHL+10]. The use of an empirical research will help in defining the characteristics of teaching quality that can be used to assess teaching. These characteristics do not instruct the teachers how to design their teaching unit but provide the criteria to do the assessment and later on the improvements. The advantage of the model is the opportunity to try different approaches and to find out which fits better to the desired results. Sometimes, this might yield to consumption of large amount of time. There are four research areas of process the quality of teaching: classroom management, learning climate and motivation, clarity/understandability and activation. These areas can be assessed by teachers, pupils and colleagues. An extra area, not directly related to the quality of teaching, is the balance sheet. It concerns the students' feedback through the questionnaire and covers the affective - emotional, motivation, and activation. So far there are no results about concrete implementation of the model in practice.

The approach from Felder and Brent considers the methodology and curricula for addressing the quality of teaching. Felder and Brent published a report on how to improve the quality of teaching [FB99]. The improvement basically relies on methodologies changes. They suggested that for each course instructional objectives should be written (following the Bloom's taxonomy of Educational Objective: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation). The use of active learning and cooperative learning were also proposed as methodologies. Beyond the methodology changes, improvement of the institutional teaching programs was also recommended. Based on such a report, the assessment of teaching quality relies primarily on the assessment of learning outcomes. The best tool for this is the collected products of students' knowledge development in the so called *portfolio*. The portfolio has twofold purpose, to demonstrate students' competences or to assess the curriculum.

Beyond the traditional forms and the assessment methods mentioned above, there are other models that do not considered teachers in particular. As a consequence, it was not possible to find out if teachers learned from the model.

In the context of universities, researchers in the field of computer science educa-

tion created maturity models to assess and to improve the curricula or the institution itself [DM11, LJAA12, LLRDH07]. The validation of these models is referred to a later stage and so far no results are published yet. Ling et al. applied their model in a case study in a private institution of Higher Learning (IHL) in Malaysia and mention that a larger participation of IHLs will be used in future for a better validation of the model [LJAA12].

Some other maturity model are created for courses design either in a classroom environment [Pet04] or online [MM04, Neu04] (still for the university domain). The model of Petri is not validated yet [Pet04]. Neuhauser did the validation of the model in relation to usability, and the answers from the questionnaires revealed that 88 percent of the responders agree with the suggested process areas [Neu04]. Similarly, Marshall and Mitchell validated the processes and the model in the analysis of an e-learning module at New Zealand University [MM04].

Likewise, in primary and secondary schools, some maturity models implementation with the focus on the institutional level or on the syllabus [Mon03, SSP13, WLLY03] were created as well. Montgomery applied her model in six schools for defining the level of using computers and technologies in schools. The models provides goals and practices for making improvements [Mon03]. Solar et al. conducted a pilot study to test the validity of the model and its associated web-support tool [SSP13]. They tested the applicability of the model in different schools and obtained positive feedback from them.

Only Chen et al. established a maturity model for observing the teaching process with the focus on the teaching process [CCC14]. Although not explicitly stated, teachers should learn from the model. In their paper, Chen et al. address the implementation of their model with teachers of tertiary education, but to the best of our knowledge, such a model has not been implemented and/or published yet.

Considering all characteristics of the aforementioned models, quality of teaching includes many components. As it was stated also by Snook et al., teachers are important to address the quality of teaching, but not the only ones [SOB+13]. We believe that the quality of teaching is a process that includes all the relevant factors of teaching, discussed separately in the models above. So, unlike the aforementioned models, but like Chen et al., the quality is addressed by looking at the teaching process as a whole. In contrast to Chen et al. this model considers not only university teachers but primary and secondary teachers as well.

2.4 Summary

This chapter provides a clear definition of the two main concepts introduced in the thesis: the *quality of teaching* and the *teaching process*. The quality of teaching is a relative term and a standard established definition of it was difficult to be

found. Most of the related research tries to define at least the attributes (elements) which contribute to the term quality. Despite different results, teachers and learners (students) are always considered as elements for addressing quality of teaching. In this research quality refers to the activities (practices) applied by teachers. It refers to the ability of students to get the content in an easier way and to their satisfaction in relation to the course.

Defining the quality of teaching was a first step toward the ways for assessing it. Based on a literature survey, different models are presented for assessing and improving the quality of teaching. Most of the works rely on one or two elements that influence the quality of teaching. Mainly the focus is either on teacher - students, or on curricula, or environment and so on. The quality is concentrated largely on teachers and students (learners) but this should include all the practices applied during teaching. This means that the whole teaching process is to be considered. For this reason, a maturity model (TeaM) which considers the teaching process with the focus on university and school teachers is provided.

3. THE TEACHING MATURITY (TeaM) MODEL

Every teacher needs to improve
not because they are not good enough,
but because they can be even better.

Dylan Wiliam

3.1 Maturity Models

The application of maturity models is straight forward to engineers, however for educators such an assessment might be new. For this reason, this section describes what Capability Maturity Model Integration (CMMI) is and how its application in practice looks like.

3.1.1 CMMI-Service

Capability Maturity Model Integration (CMMI) stemmed from the need to assess and improve the quality of products (services). After many years of research, the SEI collected and grouped together some relevant tasks and activities (by naming them Process Areas (PAs)). These tasks were further split in basic ones (named Specific Goals (SGs)) and their related activities (named Specific Practices (SPs)). The specific tasks and activities are unique to a Process Area. When talking about the generalization and standardization of processes, then some general tasks (named Generic Goals (GGs)) and related general activities (named Generic Practices (GPs)) were also defined. The latter tasks and actives are common for all Process Areas [FBS11]. The assessment of the process for producing a product (Software/Service, etc.) with this model, has a twofold orientation (Capability Level and/or Maturity Level). Capability Level means focusing on different PAs to define their CL in which their correlated specific tasks and activities are fulfilled. CMMI Service has 6 Capability Levels in a rage from 0 to 5 (see Figure 3.1). This form of assessment helps organization to concentrate for improvement only in some particular PAs. As a second orientation, CMMI Service controls the fulfillment of tasks and activities on a predefined group of PAs that correspond to a Maturity Level (ML) . Such outputs reveal at which maturity level a process for producing a service stays. Further improvement for the process means fulfillment of the group of PAs corresponding to a

higher ML [FBS11]. CMMI Service has 5 MLs in a range from 1 to 5 (see Figure 3.1).

Naturally, the question of how an assessment with maturity models looks like, might pop up. For conducting the assessment, CMMI has specific models which consist of steps of implementations. The assessment is conducted by a CMMI institute certified Assessor. The steps of the assessment start with the analysis of the requirements which determine what processes (sectors) a company wants to assess. This is followed by an appraisal plan development and a selection and preparation of a team for doing the assessment. The PAs are selected and a catalog with questions is prepared. CMMI-Services contains a total of 24 PAs and each of them has the corresponding goals and practices. This means that a catalog with several questions needs to be answered by the interviewees. Herewith, considerable time is required, and the quality and quantity of questions is important as it might influence the results for ranking the company in the appropriate maturity level. In the last steps of the implementation artifacts are obtained and the appraisal is conducted [FBS11].

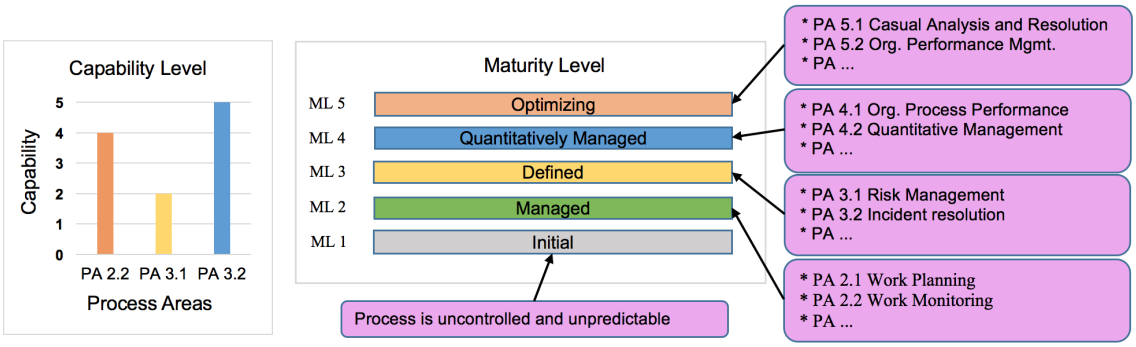

Fig. 3.1: Capability and Maturity levels in CMMI. Either process areas are analyzed and rated on a scale between 0 and 5 yielding a Capability level (to the left), or a Maturity level is reached, when fulfilling all related Process areas (to the right) [RB17].

One major problem when addressing the quality of maturity models is strictly related to the time consumption for planning, answering and conducting the appraisal. It is also related to the quality and quantity of the questions, and considerations that a rating to a maturity model might influences the company (in money, success, etc.). However, the published "appraisal results directory" from the CMMI institute manifests the usability and applicability of the CMMI model [Ins]. Software Engineering Institution put too much effort to come up with a consistent version of CMMI. It was a long process of studies and improvements within this last 30 years. Nowadays, although that the model is applied in practice, there are still parts of it being improved. It is a continuous process of improvements. The same prob-

lem holds for the TeaM model. Several studies are requisite for producing a better version of the model.

3.1.2 CMMI in Educational Institution

The concept behind CMMI inspired researchers from the computer science education sector to create maturity models. Almost all the models adapted the basic structure of how CMMI used to address quality. This means they use the concepts of PAs, SP, SG, GG, GP and the assessment through CL and ML. But, when implementing these concepts in the educational domain, they do not consider the teaching process as a whole. Most of them concentrate on particular elements of quality of teaching. Educational institution, curricula and course design are the focused elements for assessment and improvement [RB17]. Such situations hold for both university and school context.

EDUCATIONAL INSTITUTION. Duarte and Martins propose a model for process improvement of higher educational institution [DM11]. They collect PAs, goals and practices from CMMI and Business Process Maturity Model. Based on their analysis only the relevant PAs and their corresponding goals and practices where included in the model. The rest was deleted. The validation of the model is referred to in a later stage. This is planned to be applied to two or more teaching units in a Portuguese higher education institution.

Another model for rating the educational organization was created by Lutteroth et al. [LLRDH07]. Their CEMM model defines the maturity level in which the computing educational organization relies. It suggests a set of practices where the organization can make use of to further improve their performance. The authors do not present the PAs and the practices and so far the model is not validated.

An Engineering and Technology Education Capability Maturity Model is presented by Petri [Pet04]. The model aims at assessing the quality of the engineering and technology education in the Americas and to help this educational institution to improve step by step. The five CMMI levels of maturity are used in this model but no process areas and practices are presented. The validation of the model is referred to a later stage.

A similar model for quality assessment and improvement in educational institution is proposed by Manjula and Vaideeswaran [MV12]. Their CMM-QE model is validated by the PLS-Graph tool and the ML is generated by applying a k-means Cluster analysis using SPSS. Same author proposed another model named Engineering Education Capability Maturity Model (E^2 - CMM) [MV10] for improving engineering education. The model has a total of 5 CLs, 44 PAs and 234 SPs. The model will be implemented and validated in the future by using neural network.

Dounos and Bohoris also suggest maturity model for quality assurance of the educational institution [DB10]. The authors do not provide explicitly the PAs and

the practices, and the model has not yet been validated.

CURRICULUM. A maturity model for quality designing of the curriculum for higher education is proposed by Ling et al. [LJAA12]. The model is applied in a case study in a private institution of Higher Learning (IHL) in Malaysia. It mentions that a larger participation of IHLs will be used in future for a better validation of the model [LJAA12]. The authors looked at every activity included in each maturity level and on the way how each level is achieved before moving to the next level. Additionally, they used the concept of PAs and that of the best practices.

Maturity models for managing the curriculum were created for the school education as well. Solar et al. proposed ICTE - MM model for assessing the use of ICT in schools [SSP13]. The components of CMMI were used although they were referred with different names. They conducted a pilot study to test the validity of the model and its associated web-support tool. They tested the applicability of the model in different schools and obtained positive feedback from them.

The improvement of information system curriculum through CMMI was discussed in a panel by White et al. [WLLY03]. The result indicated a further extension of the CMMI processes as a basic for model curriculum in the future.

Similarly, Thing et al. propose a Curriculum Design Maturity Model (CDMM) [TYRNH12]. The model consists of PAs, SPs and of Maturity and Capability Levels. It was created as a results of a literature study, where two basic models have been reviewed, an online course maturity model and a curriculum design model. A pilot test of CDMM was run in a private institution of higher learning in Malaysia. The results showed that some improvements of the model are needed. The model will help the institution not only to assess the curriculum design, but, when required, to generate a ML for the institution itself.

COURSE DESIGN. OCDMM is a maturity model for online course design [Neu04]. The author collected the best practices for online course design following a literature review and based on six criteria the maturity levels were generated. The specific practices are not presented for the audience. Neuhauser did the validation of the model in relation to usability, and the answers from the questionnaires revealed that 88 percent of the responders agreed with the suggested process areas [Neu04].

Similarly, Marshall and Mitchell proposed the use of CMMI and SPICE for creating an e - learning maturity model. The authors validated the processes and the model in the analysis of an e - learning module at New Zealand University [MM04]. A detailed version of the model for online course design is introduced later on by Marshall [Mar10]. The E - Learning Maturity Model (eMM) helps institutions to assess and compare their capability to utilize and to maintain e - learning. The comparison with this model was conducted in New Zealand, Australia, the UK and the USA. The model make use of all the concepts from CMMI.

Likewise, in primary and secondary schools, some maturity models implementa-

tion with the focus on course design were created as well. Montgomery applied her model in six schools. The aim was to define the level of computers and technologies used in schools. The models provides goals and practices for making improvements [Mon03].

Thompson provided a maturity model to help learners to reflect on and to evaluate the effectiveness of their learning process [Tho06]. The PAs and the practices used are not presented in his publication, and the model has not yet been validated.

All the aforementioned maturity models aim at assessing and improving either the institution or the course design or the curriculum. As discussed in section 2.3, a better quality of teaching is achieved when the teaching process is considered. In this context, Chen et al. established a maturity model (T - CMM) for observing the teaching process [CCC14]. The model provides an explicit presentation of the Capability and Maturity Levels. Furthermore, from a literature survey the building block for teaching quality were defined. These buildings blocks are considered when creating the PAs and the corresponding SGs and SPs. Everything is written in details, but the model still has some restrictions. First of all, it considers only tertiary teachers. Secondly, it has a limited number of PAs. Thirdly, only an exploratory study was conducted and finally no empirical investigation is done so far.

Considering the above situation, the Teaching Maturity Model is created with the aim at overcoming the Chen et al.'s restrictions. It focuses on the teaching process and considers both university and school teachers. It covers all the PAs of the teaching process. And finally, no exploratory study was conducted but an empirical research.

3.2 TeaM Model

This section presents the basic components of the TeaM model. It shows the relevant activities and the corresponding practices.

3.2.1 TeaM Process Areas

The TeaM model stems from the necessity to have a set of standards for assessing and improving the quality of teaching in relation to the teaching process. In the TeaM model, the basic activities for teaching are named Process Areas (PAs). This actually means that the PAs represent the sub-phases from the teaching process definition (see Figure 2.1). The TeaM model has a total of 12 PAs. The 12 PAs are defined based on a study presented in details in Section 4.2. Later on the 12 PAs are reviewed by a CMMI expert and the interviewees participating in the study. The PAs cover the following objectives:

P1.1 Determining Commitment (DCOM) – The responsibilities of all relevant stakeholders are defined. The stakeholders agree about their tasks and about the syllabus they are going to introduce during the teaching process.

P1.2 Availability of Resources (AR) – The stakeholders deal with the necessary environment required during the teaching process. The environment includes the physical space (classroom with its main components, like tables, chairs, etc.) and the technical equipment that might help during teaching.

P1.3 Discovering Needs (DN) – Requirements from both, course content level and administration/organizational issues, are defined. They are established by teachers and/or the educational institution.

P2.1 Design Objectives (DO) – The aims of the course are defined. They are associated with a detailed scheme that tells what should be done. In order to measure if the course objectives are achieved, some criteria are established.

P2.2 Content Planning (CP) – The content that has to be transmitted to the pupils/students is generated. The content is structured based on the schedule.

P2.3 Methodology Selection (MS) – The teachers consider different types of teaching methodologies. They assess them and select the methods to be used during their course units.

P2.4 Incident Management (IM) – Possible problems that might occur during the teaching process are foreseen. Additionally, some corrective plans are established to overcome these problems.

P3.1 Delivery and Consolidation (DC) – Teachers conduct their teaching units and consolidate the content. They adapt it also based on new requirements that might arise during the teaching unit.

P3.2 Assessment Management (AM) – The learning outcomes are evaluated. The evaluation is done based on some predefined criteria.

P4.1 Observing the Teaching Process (OTP) – All the phases of the teaching process are assessed and measured (this excludes the assessment of the students). The results are documented.

P4.2 Reflecting on the Teaching Process (RTP) – The outcomes from the observation of the teaching process are analyzed. Corrective actions are derived in cases where there are some needs for improvement.

P4.3 Improving Teaching (IMT) – The corrective actions for improving the teaching process are implemented.

3.2.2 Specific Goals and Practices

Similar to the CMMI's PAs, the TeaM's PAs consist of Specific Goals (SGs) which include Specific Practices (SPs) and Generic Goals (GGs) which include Generic Practices (GPs). Specific Goals are unique to a PA, while Generic Goals are common for all PAs (see Figure 3.2). For instance, SG2.2.3 (DUS - Define the Unit Schedule) holds only for the Content Planning PA and not for the others. Similarly, SP2.2.3.1 (Plan the Unit Phases) holds only for SG2.2.3 of the Content Planning PA. On the other hand, GG2 (Institutionalize Reflection on Content Planning) deals with the institutionalization of Content Planning (CP), Determining Commitment (DCOM), etc. So, it holds for all PAs. The same stands for the corresponding GPs.

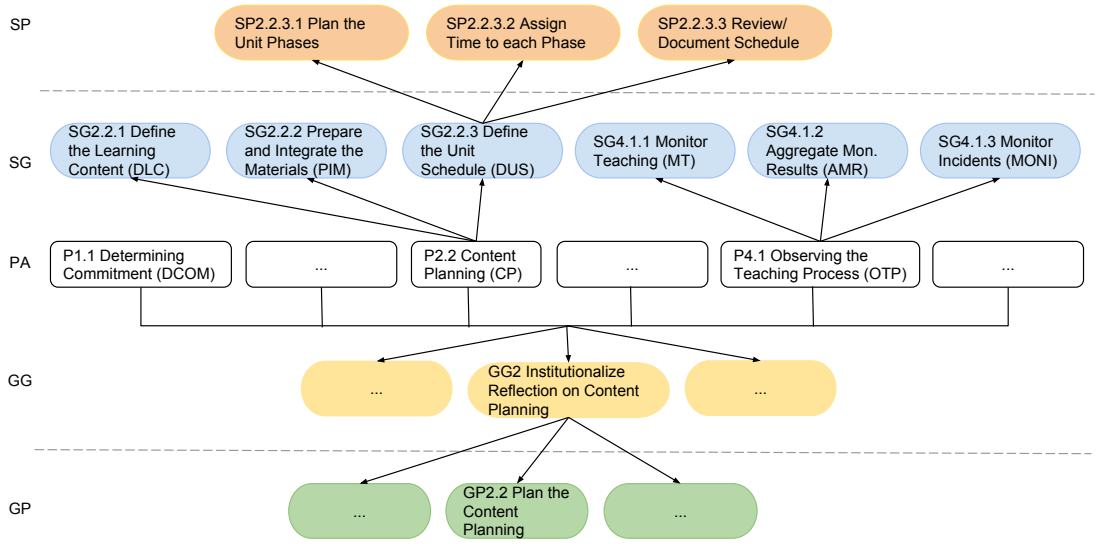

Fig. 3.2: The representation of some Specific Goals (SG)/Practices (SP) and some Generic Goals (GG)/Practices (GP) for the TeaM's PAs. GG/P hold the same for all the PAs [RB17].

In the TeaM model, a PA is satisfied when all the related SGs are achieved. The latest are achieved when their corresponding SPs are implemented. When considering the example in Figure 3.2, for instance, P2.2 Content Planning is satisfied if the SG2.2.1 Define the Learning Content, the SG2.2.2 Prepare and Integrate the Materials and the SG2.2.3 Define the Unit Schedule are achieved. Each of the mentioned SGs is achieved when the related SPs are implemented. For example, SG2.2.3 is achieved when all the three SPs (SP2.2.3.1, SP2.2.3.2, SP2.2.3.3) are implemented. Similar rule exist for SG2.2.1 and SG2.2.2 and other SGs, but their SPs are not presented in the figure with the aim at keeping the figure simple, clearly understood

and readable.

The process for defining the specific goals and practices took some time. This was looked at the second step of the study (see Section 4.2) by comparing our results (see column two of Fig. 4.2) with those of CMMI-Services (column three in Fig. 4.2) and the T-CMM (column four in Fig. 4.2). As is clearly visible, there are some PAs with the corresponding SGs that are not covered by CMMI or T-CMM. For example the DCOM (Determining Commitment) Process Area is considered in the model of CMMI but not in the T-CMM model. Also, Methodology Selection (to be found in the TeaM model) is not considered by the other models.

With that, it was able to reuse quite some of the existing goals or at least it was able to adapt them to our domain easily. Of course, missing goals had to be added and adjusted based on the interviews' results. The Specific Goals with the associated Specific Practices are presented below:

P1.1 Determining Commitment (DCOM)

SG1.1.1 Define Agreements on Duties (DAGD)

SP1.1.1.1 Establish Responsibilities and Duties

SP1.1.1.2 Check for Formal Written Forms of Duties

SG1.1.2 Agree upon Embedding into Curricula (AEC)

SP1.1.2.1 Read the Curricula and the Position of your Course

SP1.1.2.2 Coordinate with the Colleagues

SP1.1.2.3 Reflect on Content with Colleagues for Optimization

P1.2 Availability of Resources (AR)

SG1.2.1 Manage the Classroom Settings (MSC)

SP1.2.1.1 Arrange the Classroom Settings based on Methodology Used

SP1.2.1.1 Arrange the Classroom Atmosphere

SG1.2.2 Manage the Technical Infrastructure (MTI)

SP1.2.2.1 Check for the Available Technical Infrastructure

SP1.2.2.2 Plan What Devise to Use and When

P1.3 Discovering Needs (DN)

SG1.3.1 Specify the Requirements (SREQ)

SP1.3.1.1 Predefine Previous Knowledge Requirements for a Course

SP1.3.1.2 Consider Requirements from other Stakeholders

SP1.3.1.3 Document the Requirements

P2.1 Design Objectives (DO)

SG2.1.1 Define the Course Aims and the Course Plan (DCAP)

SP2.1.1.1 Control the Curricula for Defining Aims

SP2.1.1.2 Define the Year/Semester Course Plan

SG2.1.2 Define the Quantitative and Qualitative Objectives for the Course (DQQO)

SP2.1.2.1 Define Measurable Objectives for the Course

SP2.1.2.2 Define Questions for Students to Measure the Objectives

SP2.1.2.3 Conduct the Questions during the Course or at the End or Both

P2.2 Content Planning (CP)

SG2.2.1 Define the Learning Content (DLC)

SP2.2.1.1 Research and Collect Materials

SP2.2.1.2 Define Topics and Sub-topics

SP2.2.1.3 Discuss with Colleagues and Document Changes

SG2.2.2 Prepare and Integrate the Materials (PIM)

SP2.2.2.1 Select Available Materials based on the Course Aims and Content

SP2.2.2.2 Research and Integrate External Materials

SP2.2.2.3 Document the Materials

SP2.2.2.4 Discuss the Materials with Colleagues and Document Changes

SP2.2.2.5 Provide more than One Type of Materials

SG2.2.3 Define the Unit Schedule (DUS)

SP2.2.3.1 Plan the Unit Phases (lecture, practical, discussion etc.)

SP2.2.3.2 Assign Time to each Phase

SP2.2.3.3 Review and Document the Schedule

P2.3 Methodology Selection (MS)

SG2.3.1 Analyze Methodologies to be Used (AMU)

SP2.3.1.1 Search for Available Methodologies

SP2.3.1.2 Considered Advantages and Disadvantages related to your Course Objectives

SG2.3.2 Define the Methodologies to be Used (DMU)

SP2.3.2.1 Consider Methodologies Effects on Learning Outcomes and Learner's Commitments

SP2.3.2.2 Compare and Choose those that best Fits to the Course Objectives

SP2.3.2.3 Implement the Methodologies

P2.4 Incident Management (IM)

SG2.4.1 Identify Possible Problems (IPRO)

SP2.4.1.1 Consider and Document Problems on Classroom Settings/Technical Infrastructure

SP2.4.1.2 Consider and Document Problems with Unit Delivery

SG2.4.2 Analyze Possible Problems (APRO)

SP2.4.2.1 Analyze and Document the Problems

SG2.4.3 Establish Corrective Plan for Problems (ECP)

SP2.4.3.1 Define and Document a Corrective Plan for the Problems

P3.1 Delivery and Consolidation (DC)

SG3.1.1 Conduct Lessons According To Agreements/Plan (CLAA/P)

SP3.1.1.1 Follow the Plan and the Unit Schedule

SP3.1.1.2 Inform Learners about the Plan and the Schedule

SP3.1.1.3 Arrange the Plan and Schedule when Times out

SP3.1.1.4 Identify Learner's Requirements

SG3.1.2 Adapt the Lesson based on Requirements (AL)

SP3.1.2.1 Check if the Requirements Exist in the Corrective Plan

SP3.1.2.2 Solve Immediate or Direct for the Next Unit

P3.2 Assessment Management (AM)

SG3.2.1 Define the Knowledge Test Criteria for the Delivered Units (DKT)

SP3.2.1.1 Define What to Assess based on the Course Objectives

SP3.2.1.2 Define Criteria during the Creation of Topics and Sub-Topics

SP3.2.1.3 Consider Conceptual and Application Knowledge

SG3.2.2 Implement the Knowledge Test (IKT)

SP3.2.2.1 Define the Type of the Assessment (test, project, etc.)

SP3.2.2.2 Define the Form of the Assessment (online, paper and Pencil, etc.)

SP3.2.2.3 Manage the Environment Settings for the Assessment

SP3.2.2.4 Apply the Assessment

SP3.2.2.5 Analyze and Discuss the Result

SP3.2.2.6 Collect and Analyze Learner's Inputs

P4.1 Observing the Teaching Process (OTP)

SG4.1.1 Monitor Teaching (from Initialization and Preparation phase) (MT)

SP4.1.1.1 Check Time Plan during the Lesson or Directly after

SP4.1.1.2 Check Objectives compared by Learners Output

SP4.1.1.3 Check the Effect of the Teaching Methodology

SG4.1.2 Aggregate the Monitoring Results (AMR)

SP4.1.2.1 Document Results from Time Plan Observation

SP4.1.2.2 Document Results from Learners output during the Lesson or after

SP4.1.2.3 Document the Results from Teaching Methodology

SG4.1.3 Monitor Incidents (MONI)

SP4.1.3.1 Document Problems during Teaching Process

P4.2 Reflecting on the Teaching Process (RTP)

SG4.2.1 Analyze the Results (from P4.1) (AR)

SP4.2.1.1 Do a Periodically Analysis of the good and bad Experiences during Observation

SP4.2.1.2 Reflect about with Colleagues

SP4.2.1.3 Document the Results

SG4.2.2 Define Corrective Action (DCA)

SP4.2.2.1 Take Corrective Action for bad Experiences and Document

P4.3 Improve Teaching (IMT)

SG4.3.1 Improve the Agreements and the Curricula (IAGC)

SP4.3.1.1 Based on Monitor and Analysis establish Changes

SP4.3.1.2 Discuss with Colleagues

SP4.3.1.3 Document

SG4.3.2 Improve the Classroom Settings and the Technical Infrastructure (ICTI)

SP4.3.2.1 Look for new Possibilities

SP4.3.2.2 Integrate and Test them in your Environment

SP4.3.2.3 Document the Test Results

SG4.3.3 Improve the Course Aims and the Plans (ICAP)

SP4.3.3.1 Based on Monitoring and Analysis Improve on Objectives and Plans

SP4.3.3.2 Document the Improvements

SG4.3.4 Improve the Learning Content (ILC)

SP4.3.4.1 Based on Monitoring and Analysis Improve the Learning Content

SP4.3.4.2 Document the Improvement

SG4.3.5 Improve the Teaching Methodology (ITM)

SP4.3.5.1 Based on Monitoring and Analysis Define and Document if Methodology should be changed

SG4.3.6 Improve the Teachers Skills (ITS)

SP4.3.6.1 Do a periodically Training on Personal Skills

SG4.3.7 Deal with Incidents (DI)

SP4.3.7.1 Take Corrective Action for Incidents which Occurred

3.2.3 Generic Goals and Practices

The TeaM model has a twofold aim, helping teachers to improve the quality of their teaching process, or the educational organization to assess their quality by producing a raking between institutions (this when required). For this reason beyond the SGs and SPs, the TeaM model deals with standardization and institutionalization of processes. Generic Goals and Practices are defined within this scope. They were based on the CMMI's GGs and GPs but adapted to the educational domain. The TeaM model has the following Generic Goals and Practices:

GG1 Satisfy the Goals for each Process (SGP)

- GP1.1 Implement the Practices of each Process

GG2 Institutionalize Reflection on Processes (IRP)

- GP2.1 Organize Process Policy
- GP2.2 Plan the Process
- GP2.3 Supply adequate Process Resources
- GP2.4 Define Relevant Stakeholders and Assign Responsibility
- GP2.5 Monitor and Control the Process (and the Process Product)
- GP2.6 Objectively Appraise and Communicate Obedience

GG3 Institutionalize a Defined Process (IDP)

- GP3.1 Standardized the Process
- GP3.2 Collect and Include Improvements

Achieving GG1 means achieving the specific goals of a selected Process Area.

Achieving GG2 means reflecting on the management of processes associated to the PAs. This indicates that the PAs are planned and implemented in accordance to the policy, the responsibilities are assigned, resources are provided, the process is planned, controlled and monitored.

The purpose of GP2.1 is to define the organizational expectations of each process and to inform the relevant members about these expectations.

When considering the GP2.2, a plan for defining what is needed and how to perform the process is established and agreed by the relevant stakeholders.The relevant sub-practices deal with: defining and documenting the plan for performing the process; defining and documenting the process description; reviewing and agreement by the relevant stakeholders and the revision of the plan as necessary.

The purpose of GP2.3 is to ensure the necessary resources required to perform the process. The term resources refers to people, tools, and materials.

The GP2.4 deals with the establishment of the authorized and appropriate stakeholders to accomplish the process, as well as with the assignment of the responsibility for each stakeholder.

The purpose of GP2.5 is to directly monitor and control the process. This with the aim that the desired results are achieved, and when not, then corrective actions are to be taken. The sub practices suggested by CMMI Service are incorporated in our model [FBS11]. They include the following: the evaluation of the actual progress and performance against the plan for performing the process; the review of accomplishments and the results of the process against the plans for performing the process; the identification of significant deviation from the plan for performing the process; the identification of problems in the plan for performing the process; taking corrective actions when requirements and objectives are not satisfied; and chasing the corrective action.

The last GP2.6 aims at providing an objective assurance that the process is performed based on the description, standards and the procedures.

Achieving GG3 means that a standardized PA exist and can be tailored to the process that will be used. The GP3.1 describes those processes that are tailored by the set of standard processes to create instantiation. The sub practices suggested by CMMI service [FBS11] are: select from the set of standard processes those that cover the desired PAs and the needs; tailor the selected processes; the objectives should be addressed in the defined process; document the defined process and the tailoring; revise the description of the defined process when necessary.

The GP 3.2 aims at collecting related experiences and artifacts from planing and performing the process. Such experiences and artifacts can be lesson learned, measurements, suggestions for improvements and so on. The information can be stored in the process asset and can be available for all those using the same processes [FBS11].

3.3 Teaching Capability and Maturity Levels

One aspect of the TeaM model is that teaching is treated as a service where quality is of high relevance. For assessing the implementation of PAs, two representation paths are defined: a continuous representation (*Capability Level* – CL) and a stage representation (*Maturity Level* – ML). The differences between them are explained underneath.

3.3.1 Teaching Capability Levels

The continuous representation assesses and improves the process by focusing on one or more individual Process Areas. For instance, considering again Figure 3.2, one can choose to improve only the P2.2 Content Planning (CP) Process Area or P2.2

and P4.1. On the other hand, the stage representation assesses and improves the process by focusing on a predefined group of Process Areas.

The CLs, MLs and the grouping of GGs and PAs to each corresponding level was defined based on the study results presented in Chapter 4. Unlike CMMI, TeaM has four Capability Levels. CL 0 *Deficient* means that no process is implemented at all. CL 1 *Accomplished* means that the relevant processes are considered but there is no plan on how and when to implement them. CL 2 *Reflected* the processes are planned and implemented in accordance to the policy, and finally, CL 3 *Defined* means that the processes are standardized. Table 3.2 shows the features of the TeaM model related to Maturity and Capability Levels.

The Capability Level of a PA means how enduring the selected PA (or PAs) is (are) likely to be. The CL is directly related to the implementation of the Generic Goals and Practices. Table 3.1 represents such a relation.

Implementing only the SPs of a PA will lead to CL 1, which means the process is accomplished but may not last. While implementing the SPs of a PA and this based on a plan and according to the policy yield to CL 2, meaning a reflected process. So, CL measures this increase of the performance for each PAs until CL 3 (maximal) is achieved.

In comparison to Maturity Level, the advantage of CL is that teachers can choose to assess and improve only some of the PAs. Once the PAs are selected they must decide how much (selecting the appropriate CL) they want to improve the process associated to that PA. For example, a teacher chooses to reach CL 2 for P2.2 and P4.1 and CL 3 for P1.1, P3.1 and P3.2. This means that the other PAs are ignored.

3.3.2 Teaching Maturity Levels

Maturity Level indicates the improvement of the organization by meaning what CL is achieved in a wide array of PAs. The TeaM model addresses such improvement in 5 Maturity Levels. ML 1 *Chaotic* means that the teaching process is not controlled nor efficient. ML 2 *Initial* indicates a minimum level of control and efficiency of the teaching process. ML 3 *Repeatable* denotes that the teaching process is in a lower degree of standardization and monitoring. ML 4 *Stable* means that now the teaching process is standardized, monitored and controlled. ML 5 *Optimizing* indicates that the standardized teaching process is ready for continuous improvements (Table 3.2).

Each PA is assigned to a Maturity Level. The results of the study presented in Section 4.3.3, where the applicability of the TeaM was tested in practices, demonstrate the final version of how PAs are split in their corresponding MLs (see Table 3.3, column one and two).

Continues representation is limited in its ability to produce a comparison between teachers' performance. This might happen only if each teacher select the same PAs. For this reason stage representation (ML) is mostly used as it provides a predefined

Tab. 3.1: The relation between Capability Levels and Generic Goals

Capability Levels	Generic Goals
CL 0: Deficient	
CL 1: Accomplished	GG 1 All SPs in the PA
CL 2: Reflected	GG 1 All SPs in the PA GG 2 GP 2.1, 2.2, 2.3, 2.4, 2.5 and 2.6
CL 3: Defined	GG 1 All SPs in the PA GG 2 GP 2.1, 2.2, 2.3, 2.4, 2.5 and 2.6 GG 3 GP 3.1 and 3.2

sets of PAs. However a combination of Capability and Maturity Levels is possible and this is called "Equivalent Staging". So unlike CL, ML concentrates in assessing the implementation of a group of PAs. For example a teacher wants to achieve ML 2 and as a consequence the related PAs of this level has to be implemented. This means that all the goals of PAs: AR, DO, CP, DC, AM and DCOM should be satisfied and the Generic Goal 2 belonging to that ML should be achieved (Table 3.3).

Based on the concept of equivalent staging, the ML denotes the implementation of PAs by the mean of a Capability Level. On the other hand, each CL is related to a Generic Goal, this mean that also each ML is indirectly associated to Generic Goals (see column three in Table 3.3). This signifies that for reaching ML 2 (Initial) all the PAs assigned to this level must reach CL 2 (or even better CL 3). For achieving ML 3 all the PAs assigned to that level must reach CL 3. The maximal Capability Level (CL 3) has to be reached also from the PAs of ML 4 and 5. This means that when using Capability Levels, a high maturity is attained by applying the equivalent staging concept.

When using Maturity Levels, a high maturity is attained when ML 4 or ML 5 is achieved. A Process Area should be satisfied in order to pretend its Maturity. In other words, the corresponding sets of Specific Practices associated to a Specific Goal should be fulfilled. A Maturity Level is achieved when all the Process Areas assigned to that level and to the previous MLs are implemented. For instance,

Tab. 3.2: The Capability and Maturity Levels of TeaM

Level	Capability Level	Maturity Level
0	Deficient - None of the relevant factors of the teaching process are implemented.	
1	Accomplished - The relevant factors of the teaching process are taken into consideration but there is no plan on implementing them.	Chaotic - the teaching process is neither controlled nor efficient.
2	Reflected - The relevant factors of the teaching process are planned and implemented in accordance to the policy. There is the plan for performing the process, resources are provided, responsibilities are taken, is controlled and monitored.	Initial - the teaching process is under minor control and little efficiency.
3	Defined - The relevant factors of the teaching process are standardized.	Repeatable - the teaching process is sparsely standardized and monitored.
4		Stable - the teaching process is standardized, monitored and controlled.
5		Optimizing - the teaching process is continuously improved and ready for further teaching process upgrades.

Tab. 3.3: The relevant Process Areas for each Maturity Level

Maturity Levels	Process Areas	Capability Levels
Chaotic (1)	No relevant PAs	
Initial (2)	Availability of Resources (AR) Design Objectives (DO) Content Planning (CP) Delivery and Consolidation (DC) Assessment Management (AM) Determining Commitment (DCOM)	CL 2 (GG 2)
Repeatable (3)	Discovering Needs (DN) Incident Management (IM)	CL 2 (GG 2) CL 3 (GG 3)
Stable (4)	Methodology Selection (MS) Observing the Teaching Process (OTP)	CL 2 (GG 2) CL 3 (GG 3)
Optimizing (5)	Reflecting on the Teaching Process (RTP) Improving Teaching (IMT)	CL 2 (GG 2) CL 3 (GG 3)

reaching Maturity Level 4 (Stable), each of the Process Area assigned to Maturity Level 2 (AR, DO, CP, DC, AM, DCOM), to the Maturity Level 3 (DN, IM) and to the ML 4 (MS, OTP) must be implemented. The implementation of the PAs is repeated until ML 5 is reached.

Figure 3.3 shows a case study of an informatics teacher named Anna. It assumes that Anna is at ML2 because she implements the PAs related to this level. She manages the classroom and the technical infrastructure. She clearly establishes the objectives and the plan of the course. She defines the learning content and the materials needed for the course. Furthermore she conducts the units based on the predefined plan and defines the criteria to test the learns' outcomes based on the units she delivered. And finally, she knows her duties and agrees on the curricula. In order to mature with one level, the TeaM model makes it explicitly clear what she has to do to reach the ML3. When using ML for obtaining higher maturity, then Anna should repeat the implementation of all the activities in ML 2 and additionally should implement those related to ML 3. This means that she should additionally specify the previous knowledge required to follow a course. She should identify and analyze possible problems that might occur during teaching and provide remedial actions to the problems.

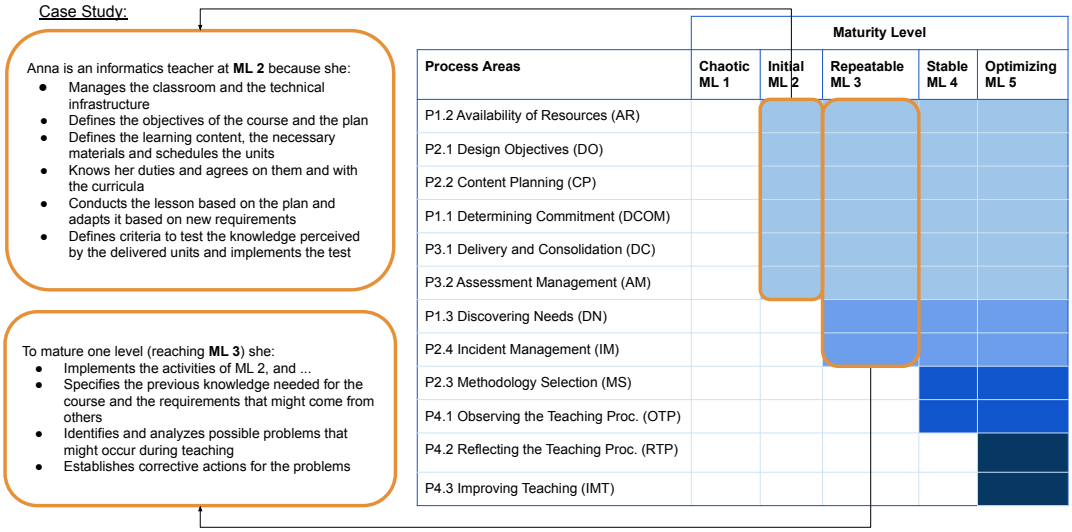

Fig. 3.3: A down-scaled example of a teacher, whose assessment yields a Maturity Level of 2, and showing what is to be done by her in order to reach Maturity Level 3.

3.4 Relation among Process Areas

When talking about the standardization and institutionalization of the processes, then Generic Goals and Practices are expected components to be achieved and applied to all the PAs. They work as reminders to do things right [FBS11]. For example, considering the "GP2.2 Plan the Process". When applied to the PA "P2.2 Content Planning", the practice reminds to plan the activities for planning the content which should be transmitted to the pupils/students. When applied to the PA "P3.1 Delivery and Consolidation", the same practice reminds to plan the activities for conducting the teaching units.

During the improvement process, the interaction between Generic Practices and their related PAs is of importance. There are PAs that support Generic Practices. Due to the dependences that GPs have on their related PAs, it might happen that the PAs are implemented before the GPs [FBS11]. For instance the SG1.1.1 of the PA "Determining Commitment" defines the roles, duties and responsibilities for each stakeholder. This means that this PA can fully implement the GP2.4 (Define Relevant Stakeholders and Assign Responsibility). Such relations are presented in Table 3.4.

Except for the relationships PAs and GPs, the PAs itself have relations among them. Although they are grouped into their corresponding phase of the teaching process (see the definition of the Teaching Process, Figure 2.1), there are cases when a PA of one group depends on a PA from the other group. Figure 3.4 represents

such relationships. For instance, P2.2 Content Planning (CP) operates as a center of relation, due to its largest dependences with the other PAs. CP defines the materials and the units for the learning content. For this reason it depends on the objective of the course established by the DO. While designing the learning content the methodology should be considered (dependency with MS). Most of the courses require some previous knowledge and this makes it related also to DN. Another interdependency is between the learning content and the assessment of the learning content (AM). It is also very important to conduct the lesson following the plan (dependency with DC). Last but not least, the process should be monitored (OTP) and improved based on the results (IMT).

Such relationships between PAs, and their relationships with the GGs should be considered when talking about institutionalization and standardization of the teaching processes. This means the use of the TeaM model as a comparison tool to generate a ranking of the educational institutions based on best performance, and/or to generate a ranking of best performance teachers.

Tab. 3.4: Generic Practice and Process Area Relationships

Generic Practice	Roles of PAs in the implementation of GPs	How GP applies to its related PA
GP2.2 Plan the Process	**Design Objective:** the PA implements partially the GP2.2 due to SG2.1.1 where the course is planned.	GP2.2 applied to the design objective SG2.1.1 can be characterized as "plan the plan for the course activities".
	Content Planning: the content planning PA plans all the necessary resources to conduct teaching	GP2.2 applied to this PA means "plan the planning of the content".
	Delivery and Consolidation: the SP3.1.1.2 and SP3.1.1.3 of this PA implement only the last sub - practice of GP2.2, meaning that the plan should be rearrange when is necessary.	
	Improve Teaching: the SG4.3.3 of this PA implements also the last sub - practice of GP2.2.	

Table 3.4: Generic Practice and Process Area Relationships, continued

Generic Practice	Roles of PAs in the implementation of GPs	How GP applies to its related PA
GP2.3 Supply adequate Process Resources	**Availability of Resources:** this PA implements partially the GP2.3 because teachers, students, pupils and the teaching materials are not included. **Content Planning:** the SG2.2.2 of this PA also implements partially the GP2.3 because it considers only the preparation and the integration of the teaching materials. The other resources are not considered.	
GP2.4 Define Relevant Stakeholders and Assign Responsibility	**Determining Commitment:** the SG1.1.1. fully implements the GP2.4. It defines the role of each stakeholder and their duties and responsibilities.	
GP2.5 Monitor and Control the Process	**Observing the Teaching Process:** The PA implements partially the GP2.5. Only the two last sub - practices of this GP are not considered by this PA. **Reflecting on the Teaching Process:** the SG4.2.2 of this PA considers also the corrective action when the desired results are not achieved. **Improve Teaching:** the SG4.3.3. satisfied one of the sub - practices of GP2.5. It improves the course goals and the plan as necessary. The implementation of one sub - practice of GP2.5 is also implemented by SG4.3.7 where corrective actions are taken in case of incidents.	GP2.5 applied to the monitoring and controlling the process covers the monitoring and controlling of observing the teaching process activities.

Table 3.4: Generic Practice and Process Area Relationships, continued

Generic Practice	Roles of PAs in the implementation of GPs	How GP applies to its related PA
GP2.6 Objectively Appraise and Communicate Obedience	**Reflecting on the Teaching Process:** the PA partially implements the GP2.6. It analyses the results collected from monitoring and controlling the teaching process.	
GP3.2 Collect and Include Improvements	**Determining Commitment:** only the SP1.1.2.2 and the SP1.1.2.3 of the PA implement partially the GP3.2, where reflection on the teaching content is suggested for optimization. **Observing the Teaching Process:** the two SGs of this PA (SG4.1.2 and SG4.1.3) partially implement the GP3.2 by aggregating the monitoring results and documenting the problems during the teaching process. **Reflecting on the Teaching Process:** the SG4.2.1 contributes to the partially implementation of the GP3.2 by analyzing the results from monitoring the teaching process. **Improve Teaching:** all the SGs of the PA (with exception of SP4.3.6.1 and SP4.3.7.1) help to fulfill the GP3.2.	

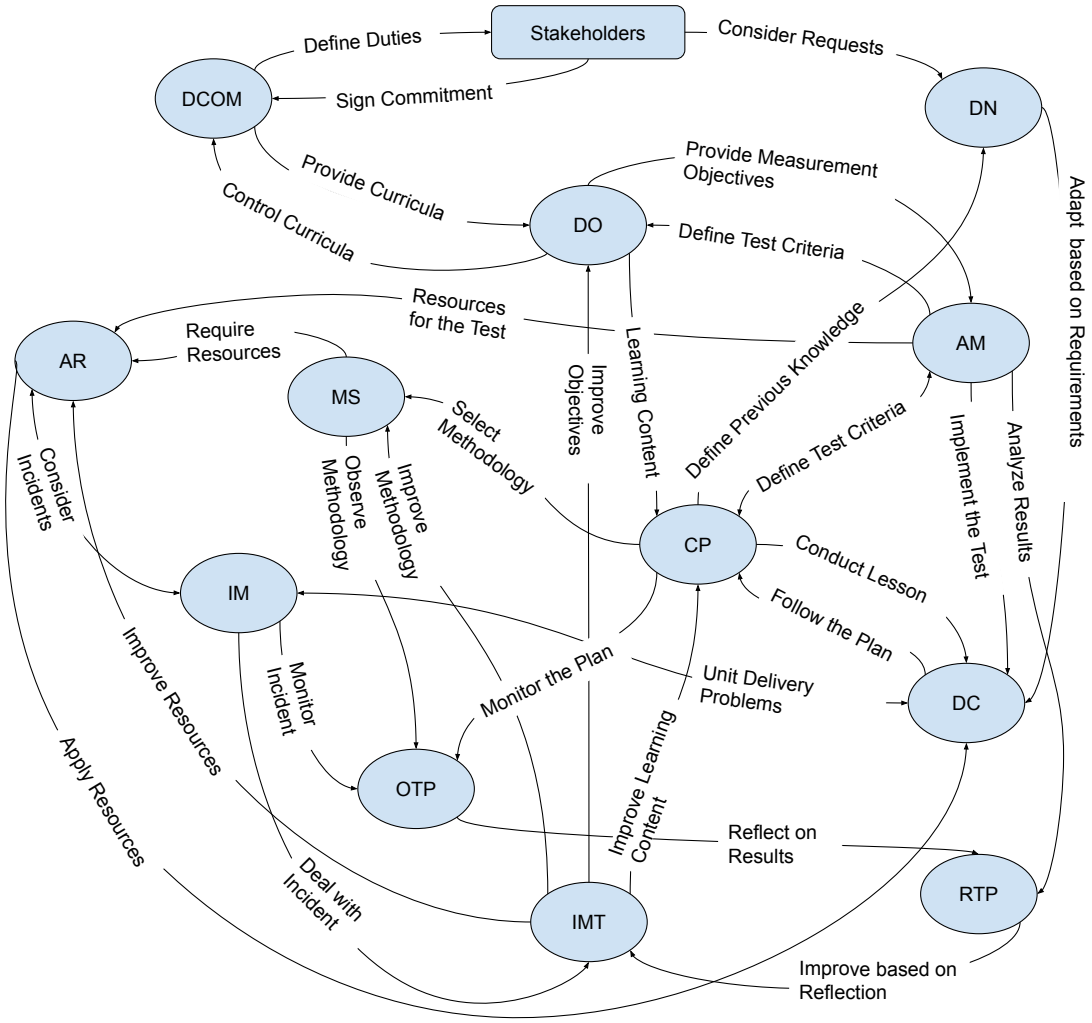

Fig. 3.4: The relationships between Process Areas of the TeaM model.

4. EVALUATION

4.1 Evaluation Structure

The evaluation of the TeaM model went through three main steps, and each step consists of some further steps. This is presented graphically in Figure 4.1. The reason why three main steps were considered is related to this thesis' objective. We want to show that the use of a maturity model helps to improve the quality of teaching, and this, by implicitly assessing the teaching process. For this reason, as a first step, the creation of the TeaM model was established. Furthermore, with such a model is aimed to assess and improve the quality in university and schools in Charinthia. This relates to the evaluation of the TeaM model in university (second step) and schools (third step).

A detailed explanation of how the TeaM model was created, is to be found in Section 4.2. The second main step, associated to the the evaluation of TeaM in university, is described in Section 4.3. The third main step, presenting the evaluation of the TeaM in schools, is introduced in Section 4.4.

4.2 The Creation of the TeaM Model

The quality of teaching is relevant for informatics classes, and the teaching process is an important element that influences it. For this reason, the TeaM model was created to assess such a process. The aim of this step was twofold [RB17]:

- Improving the quality of teaching by looking closer at teaching as a process. This means to decompose the teaching process into sub-processes and to define goals supporting these processes.
- Presenting an (understandable as well as acceptable) maturity model for informatics teachers. This includes the definition (and verification) of best practices supporting the teaching process.

When using a maturity model, it is assumed that (a) the management of the teaching process influences the way of improving informatics classes, and (b) doing real assessments helps finding out whether the model is understandable and acceptable by informatics teachers. Under these assumptions, this leads to the following question that needed to be answered [RB17]:

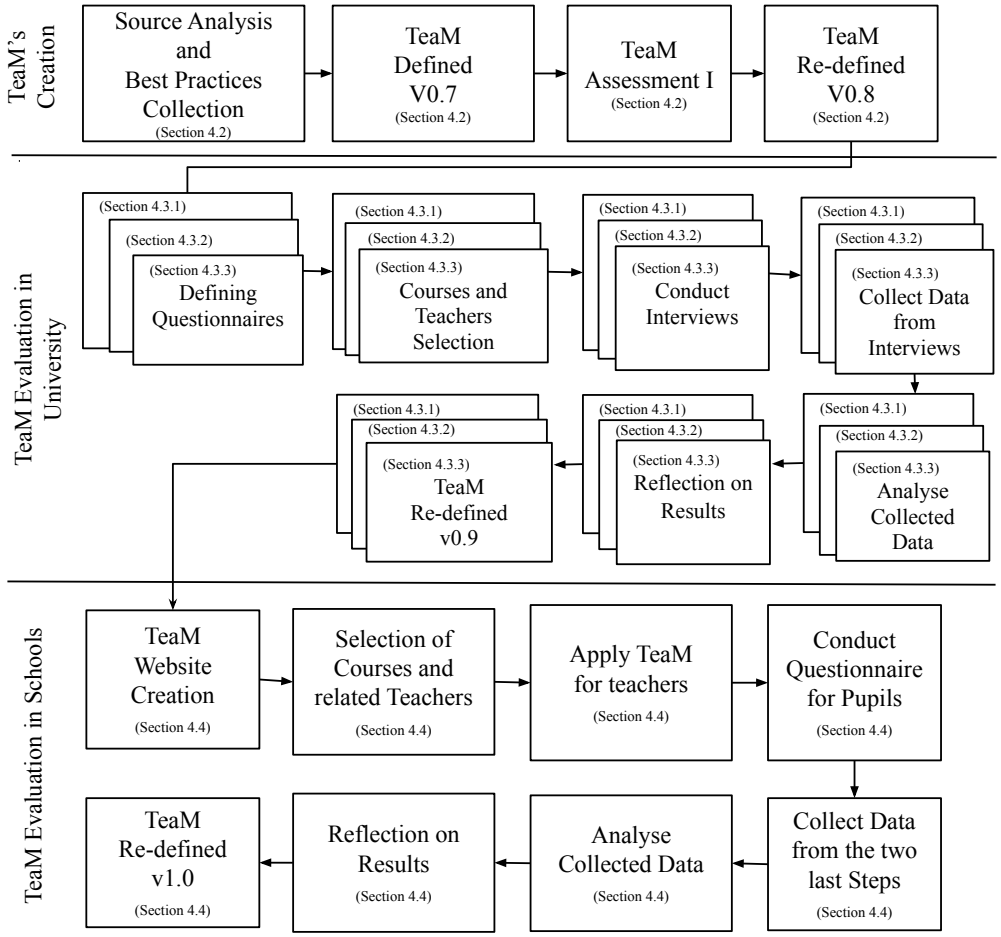

Fig. 4.1: The steps for creating and evaluating the TeaM model.

- How should a maturity model that aims at improving the teaching in informatics-classes looks like?

Implicitly, two more questions were then in the focus of the research:

- Are the specific goals and practices defined in the model perceived useful, are any missing?
- To what extent is the TeaM model understandable and acceptable by informatics teachers?

For coming up with a first version of the TeaM model, the research in the first main step was divided into three tasks [RB17]:

- In the first task, a literature survey was conducted for defining the basic (and relevant) phases and sub-phases of a teaching process. From this, a first list of PAs was generated.

- In a follow - up task, a working version of the TeaM model was created by considering the result of the first task, the content of the model of Chen et al. (T-CMM) [CCC14] and the CMMI-service model [FBS11]. Additionally, that version of the TeaM model was evaluated and improved by a CMMI expert.

- In the third task, a survey for assessing the model with informatics teachers was prepared. For the assessment, every goal of the TeaM model established in the second phase was mapped to several questions (see Appendix A Pre-Study Questionnaire). Both, the questionnaire and the TeaM model, were given to the interviewees. The aim of the questionnaire was to test the understanding and acceptability of the model, and to collect a set of best practices from their experiences.

4.2.1 Settings

As mentioned above, the first task of the TeaM approach consisted of a literature survey where the teaching model of Meyer and Hilbert [Mey16] (in German) operates as pillar for creating the skeleton of the TeaM model. Moreover, in the same task, a comparison between the TeaM model, the CMMI-service and T-CMM model (see Figure 4.2) were considered in order to polish the TeaM model. The model was then checked by an international renowned CMMI expert teaching at our University, and it was additionally reflected on during a CMMI training that took place in Germany end of 2016. After correction, the output of this task then formed the first working version of our model.

The first working version of the model was taken as the basis for a questionnaire. The questionnaire had the objectives to check if informatics teachers agree with this model, to provide feedback for improvements and to collect additional practices from the teachers' experiences. The questions are presented in Appendix A. The questionnaire was split into four main parts (corresponding to the four phases of the teaching process). Each part contained questions about the goals associated with each practice of the corresponding teaching process' phases.

For the assessment itself a survey involving different types of lecturers was planned. In the survey four teachers with a lot of different experience participated. All of them were active in the field of curricula development and competency models in Austria. They all are males, and two of them have long-time experience in teaching informatics and mathematics in primary and secondary schools. The two other lecturers are teachers in informatics-didactics at Universität Klagenfurt.

Tab. 4.1: The relevant Process Areas for each Maturity Level deduced by the first step of the research

Maturity Level	Process Areas
Chaotic (1)	No relevant PAs.
Initial (2)	Availability of Resources (AR) Design Objectives (DO) Content Planning (CP) Methodology Selection (MS) Delivery and Consolidation (DC) Assessment Management (AM)
Repeatable (3)	Determining Commitment (DCOM) Discovering Needs (DN) Incident Management (IM) Observing the Teaching Process (OTP)
Stable (4)	Reflecting on the Teaching Process (RTP)
Optimizing (5)	Improving Teaching (IMT)

Every interview lasted about 90 minutes. The same interviewer conducted the interviews, and every input from the interviewees was documented in written form.

4.2.2 Results

For creating the TeaM model, the CMMI's basic terminology and structure (PAs, SP, SG, GP, GG, CL, ML) was used, but what was missing, was the definition of each of them (suitable to the computer science education domain). As a result of the first task it was possible to provide the definition of the "Teaching Process", already presented in Section 2.1.

Consequently, the TeaM's Process Areas were also created by this task. The latest version of the TeaM model has a total of 12 PAs, derived from the first task of the research and reviewed later on by the CMMI expert and the interviewees. Their properties are explained in details in Section 3.2.1. As an output of the second and third tasks, it was possible to define the TeaM's Specific Goals and Practices (see Subsection 3.2.2). The interviews and the questionnaire at the third task of the research then made it clear that one specific goal, Manage Incidents (MI) had to be replaced by the specific goal Deal with Incidents (DI).

In the second task of the research a comparison of TeaM's results (see column two of Figure 4.2) with those of CMMI-Services (column three in Figure 4.2) and

TeaM PAs	TeaM-Specific Goals	CMMI PAs	T-CMM (Chen)
P1.1 Determining Commitment (DCOM)	-Define Agreements on Duties (DAGD) -Agree upon Embedding into Curricula (AEC)	SD STSM	
P1.2 Availability of Resources (AR)	-Manage the Classroom Settings (MCS) -Manage the Technical Infrastructure (MTI)	SSD, CAM	CMC (SG 2)
P1.3 Discovering Needs (DN)	-Specify the Requirements (SREQ)	(REQM)*SSD	Course req.dev(CRD)
P2.1 Design Objectives (DO)	-Define the Course Aims and the Course Plan (DCAP) -Define the Quantitative and Qualitative Objectives for the Course (DQQO)	QWM WP WP	Course & Teaching P.(CTP) QCM
P2.2 Content Planning (CP)	-Define the Learning Content (DLC) -Prepare and Integrate the Materials (PIM) -Define the Unit Schedule (DUS)		CTP CM ICTM
P2.3 Methodology Selection (MS)	-Analyze Methodologies to be Used (AMU) -Define the Methodologies to be Used (DMU)		
P2.4 Incident Management (IM)	-Identify Possible Problems (IPRO) -Analyze Possible Problems (APRO) -Establish Corrective Plan for Problems (ECP)	RSKM SCON	CTP
P3.1 Delivery and Consolidation (DC)	-Conduct Lessons According to Agreements/Plan (CLAA/P) -Adapt the Lessons based on Requirements (AL)	 REQM	
P3.2 Assessment Management (AM)	-Define the Knowledge Test Criteria for the Delivered Units (DKT) -Implement the Knowledge Test (IKT)	MA	Learn. Verif. & Teach. Val. (VAL)
P4.1 Observing the Teaching Process (OTP)	-Monitor Teaching (against goals/plans in initialization & preparation phase) (MT) -Aggregate the Monitoring Results (AMR) -Monitor Incidents (MONI)	PPQA (based on commitments) WMC MA DAR MA	Course M & C (CMC)
P4.2 Reflecting on the Teaching Process (RTP)	-Analyze the Results (from Observing the Teaching Process) (AR) -Define Corrective Actions (DCA)	IRP CAR CM DAR	
P4.3 Improving Teaching (IMT)	-Improve the Agreements and the Curricula (IAGC) -Improve the Classroom Settings and the Technical Infrastructure (ICTI) -Improve the Course Aims and the Plans (ICAP) -Improve the Learning Content (ILC) -Improve the Teaching Methodology (ITM) -Improve the Teachers Skills (ITS) -Deal with Incidents (DI)	 OT OPF	Teach.Proc. Focus (TPF) Teaching Innovation (TIA)

Fig. 4.2: Process Areas and Specific Goals of the TeaM model (first two columns). The table also presents the differences and commonalities between the TeaM, the CMMI [FBS11] (third column) and the T-CMM [CCC14] (fourth column) models.

the T-CMM (column four in Figure 4.2) was done. As clearly visible, there are some PAs with the corresponding SGs that are not covered by CMMI or T-CMM. For example the DCOM (Determining Commitment) Process Area is considered in the model of CMMI but not in the T-CMM model. Also, Methodology Selection (to be found in the TeaM model) is not considered by the other models.

From the second task and from the feedback of the CMMI-expert, it was possible to define the TeaM's own Maturity and Capability Levels (see Section 3.3). The results were analyzed and help on defining what level of maturity belongs to each PAs. The first version looks like in Table 4.1. Later research demonstrated that a rearrangement of grouping the PAs into their MLs was necessary. Now, the latest version is shown in Table 3.3.

4.2.3 Discussions

The results from the first step of the research demonstrated that the interviewers liked the intention behind each assessment-question. Questions related to incident management, were appraised as a good issue to be taken in consideration during the teaching process in informatics. Asking them about how skeptical they are about concerns of teachers being assessed (and thus if this model will be used by teachers) they shared the concerns. The model could help informatics teachers in improving their quality of teaching, but it should not be used as a model for ranking and for competition. Well, the first aim of TeaM model is to operate as a self assessment tool for teachers in order to check their level of quality of teaching. They also can define by themselves which level they want to achieve, by simply implementing the TeaM's practices related to each level [RB17]. Maybe later research will show the ranking function of the model, when required.

The main question was if it is possible to create a maturity model that could, in a follow-up step, help in improving teaching in informatics classes. Such a model was presented and, as some necessary preliminary work, the conducted interviews showed that such a model can be constructed [RB17].

The two remaining questions about completeness and usefulness/acceptability were also answered positively during the interviews. All the interviewees gave almost the same answers, making it easier to come up with unanimous practices and goals [RB17].

4.2.4 Threads of Validity

For the implementation of this step different informatics lectures, with different characteristics were selected. The only factor that might have contributed to the results is the number of teachers participating in the establishment of practices of the model, and its evaluation. Collecting the experiences and the opinions of only

4 teachers might be not the ideal setting but all the answers were quite similar, facilitating the creation of SPs of the model.

The questionnaire remained the same until the end of this first step and it took no more than one week to interview all the lectures. Although the interviewees have different physical working places, we cannot guarantee that they had not spoken to each other, influencing the results.

Beyond the low number of participating teachers, it turned out that the model proved useful. The terminology used was clear and not ambiguous, making it understandable and acceptable [RB17]. Further evaluation of the model with larger participation is addressed in the follow-up researches.

To conclude, the first step of the research in this thesis resulted in the creation of the TeaM model version v0.8. Within the scope of the TeaM model, the below sections present its evaluation in the university and school context.

4.3 TeaM Assessment at Universities

The second step of the research represents the application of the TeaM model in some lectures at Universität Klagenfurt (Figure 4.1). Eventually two researches precede that of using TeaM as a tool to test quality of teaching. The first research stems from the fact that the major part of the PAs, goals and practicies of the TeaM model were defined by school teachers. For that, an interested point was to check the compatibility of the TeaM practices between university and school teachers, if there are similarities or differences in their practices of teaching. Such research is presented in the Section 4.3.1. The second one, tests the acceptability of the TeaM model in the university domain (Section 4.3.2), and their results define the willingness of university teachers to use TeaM as a tool for generating the quality of their teaching. As a consequence then, Section 4.3.3 presents the research of applying TeaM model in some informatics bachelor and master classes at Universität Klagenfurt.

4.3.1 TeaM Assessment - Differences between University and School Teachers

Quality assurance is a goal for both, university and school teachers, even though they have different learners and teach different content. The focus of the TeaM model on university and school teachers, makes it an appropriate tool to address the quality. The objective of this research was to investigate if, considering the TeaM model, informatics university teachers can learn from informatics school teachers, and vice versa [RB18b].

Due to the fact that the major part of the Specific Practices of the TeaM model were mainly defined by informatics school teachers, the question now is, if the TeaM model is appropriate for all types of teachers. Furthermore, it was interesting to

investigate which practices are useful, useless, and eventually also new for both types of teachers. The objective was to deal with this question and to see which practices and goals of the model are shared and which, eventually, could be shared in order to improve the way of teaching. So, within this scope the following question is raised [RB18b]:

- To what extent do the informatics university and schools teachers differ in their way of teaching (and what could they learn from each other)?

For answering the question, the TeaM model was applied to lectures at the Universität Klagenfurt, looking at their maturity level in detail and comparing it with the official rating of their classes [RB18b].

Settings

For conducting the research, 19 informatics courses from the Bachelor and Master program at the Universität Klagenfurt were selected. A questionnaire covering the practices and goals of the TeaM model was distributed to the lecturers of these courses. The questions were answered by the teachers in the presence of members of the department of informatics - didactics. It is worth to mention that at the beginning of each interview was clearly stated that the aim of the questionnaire was not to assess the quality of teaching but to check if and what teachers can learn from the model. The questions required "Yes/No" answers, but free-text answers were allowed and, for later analysis, recorded [RB18b].

As already mentioned, the TeaM model has 12 Process Areas (PAs), and each PA contains one or more goals to be fulfilled during the teaching process. The goals itself contain practices. And, every practice was associated with one question. For instance "SP2.2.1.1 Research and collect materials" was transformed in the questionnaire "Q18. For defining the learning content, do you search for and collect materials?". In total there were 76 questions. The questions were provided in an electronic format using Google forms, and are accessible in this link [Que18]. This makes the questionnaire public by those who are interested to use such a model. The participation is anonymous as no personal data is collected.

The questionnaire itself was divided in two parts. First, the 19 interviewees answered the corresponding "Yes/No" questions according to the practices. Secondly, they were invited to provide their opinion or suggestions concerning the practices, goals or the way of how they are assigned to Maturity Levels. All the answers from the interviewees were collected in an electronic form [RB18b].

Results

Due to the size of the TeaM's practices (76 practices), the results are generalized and presented within their corresponding 31 TeaM goals (running from SG1.1 up to

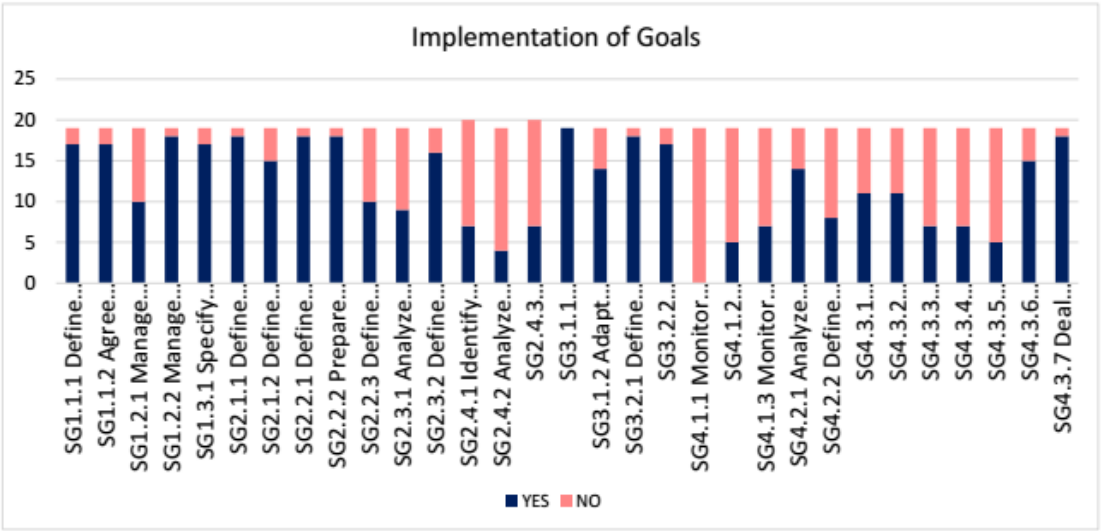

Fig. 4.3: The number of interviewees who did or did not implement the TeaM model's goals. In total, 19 university teachers interviewed [RB18b].

SG4.3, see Figure 4.3 for an overview). While a detailed description of the results is presented below [RB18b]:

Feedback from Teachers

During the **initialization phase** of the teaching process, stakeholders think about their commitments (like defining their duties, checking the related curricula, etc.). Two goals are associated to it: *G1.1.1: Define Agreements on Duties* and *G1.1.2: Agree upon Embedding into Curricula*. Almost all the 19 interviewees (except 2) were aware and agreed about implementing the related practices . Another set of questions tangles the resources needed during the teaching process. More concretely, the goals are *SG1.2.1 Manage the Classroom Settings* and *SG1.2.2 Manage the Technical Infrastructure*. Half of the interviewees do not think about arranging the classroom settings based on the methodology they used, as methodology is stable to them. On the other side they take care to provide an adequate atmosphere in the classroom and to use technical infrastructure. *SG1.3.1 Specify the Requirements* is another goal that deals with the predefinition of the knowledge students should have before starting a course, with the requirements that might come from other stakeholders and with their documentation. Almost all of the university lecturers do not implement only the documentation practice, while the other practices are fully fulfilled.

In the second phase of the teaching process (**preparation phase**), important goals of the lecture are related with the design of the course objectives (like course

aim, course plan, measurable objectives, etc.). The two goals *SG2.1.1 Define the Course Aims and the Course Plan* and *SG2.1.2 Define the Quantitative and Qualitative Objectives for the Course* are known and implemented by the lecturers. Planning the content of the course is another process required during the second phase. The goals are: *SG2.2.1 Define the Learning Content*, *SG2.2.2 Prepare and Integrate the Materials* and *SG2.2.3 Define the Unit Schedule*. This includes all the steps like defining the course materials, topics and sub-topics, external material, a plan of the unit phases, etc. These goals include also documentation of the practices. What is noticeable here is the fact that almost all the lectures are aware of such practices, implement most of them, but still do not consider those practices that require a documentation. One such example is "Assign time to each unit phase and document the schedule". Only 4 out of 19 lectures do it that way. Methodology selection deals with two goals: *SG2.3.1 Analyze Methodologies to be Used* and *SG2.3.2 Define the Methodologies to be Used*. This implies searching for available (suitable) methodologies, their advantages and disadvantages, their effects on the learning outcomes, etc. Ten from the lecturers do not deal with methodologies and consider them in their teaching process. They stick to the one they have been using for a while. However, they try to implement the rest of the practices. The good news is that nine lecturers look for methods of teaching and, when suitable, do implement them. Management of the risk is the last sub-process considered in the *preparation phase*. *SG2.4.1 Identify Possible Problems*, *SG2.4.2 Analyze Possible Problems* and *SG2.4.3 Establish Corrective Plan for Problems* are the goals related to this sub-process. The practices here consider problems in the classroom, with infrastructure, during unit delivery, and also their analysis, corrective plan and related documentation. Also, here is noticeable that the major part of the lecturers (13 of them) do not think about and document possible problems that might occur.

The third phase of the teaching process (**enactment**), comprises only two Process Areas. In the first PA the delivery and consolidation of the unit based on the schedule, plan, requirements, etc is established. It has two goals: *SG3.1.1 Conduct Lessons According To Agreements/Plan* and *SG3.1.2 Adapt the Lesson based on Requirements*. The results from the questionnaire shows that all the lecturers implements at least one practices, and four of them do not consider to adapt the lecture according to a corrective plan. As they do not consider possible requirement changes during their preparation phase they do not think about a following a plan. In the second PA the assessment is managed. The two goals *SG3.2.1 Define the Knowledge Test Criteria for the Delivered Units* and *SG3.2.2 Implement the Knowledge Test* deal mainly with practices like the definition of criteria for an assessment, type and form of an assessment, the implementation of the assessment, collection and analysis of results, etc. The lecturers interviewed are familiar with these practices and implement all of them during their teaching.

The last phase of the teaching process is **quality and incident control**. One

necessary process is the observation of the teaching process. The related goals are: *SG4.1.1 Monitor Teaching (from Initialization and Preparation phase)*, *SG4.1.2 Aggregate the Monitoring Results* and *SG4.1.3 Monitor Incidents*. As their names reveal, the practices deal with the time plan of courses, objectives, methodologies, documentation from the observation and the problems during teaching, etc. The results from the interview show that only two practices are fully implemented by the lecturers. The documentation practices are again not considered at all from almost all the interviewees. As a results, this PA is basically unknown to university teachers. After the observation process, a reflection is necessary. All this is done in order to learn from the sub-processes, reflect on them and to improve teaching at the end. *SG4.2.1 Analyze the results* and *SG4.2.2 Define corrective action* are the two goals of the sub-process. The practices suggest to do periodically analysis of the experiences during observation, to reflect about with colleagues, document the results, think about corrective plans for incidents, etc. The results show that only two practices are implemented. The practices related to the documentation and corrective plan for incidents are not implemented by a considerable part of the lecturers. They explained this with the arguments that bad experiences are directly solved and no further analysis and documentation is needed. The improvement of the teaching process is the last area considered in the TeaM model. It contains seven goals: *SG4.3.1 Improve the Agreements and the Curricula*, *SG4.3.2 Improve the Classroom Settings and the Technical Infrastructure*, *SG4.3.3 Improve the Course Aims and the Plans*, *SG4.3.4 Improve the Learning Content*, *SG4.3.5 Improve the Teaching Methodology*, *SG4.3.6 Improve the Teachers Skills*, and *SG4.3.7 Deal with Incidents*. So basically, the practices point at the improvement of curricula, classroom settings, infrastructure, course aim and plan, the learning content of the course, methodology, personal training, documentation of all these practices, etc. Some of the practices are implemented by the lecturers, but when it comes to documentation again, nearly none of them does do it. It is also interesting to mention the fact that four lecturers do not do further personal training during their career (*SG4.3.6 Improve the Teachers Skills*).

Interviewees Suggestions and Comments

At the end of the questionnaire the interviewees had the chance to provide feedback and suggestions for the model. Different interviewees gave different suggestions that were collected and assigned to answer categories. Looking at the results, a considerable part of the practices are known and implemented by the teachers. But, the documentation practices are seen as more problematic and not favorable by the lecturers.

Documentation seems to be an issue. One interviewee suggested to rethink the practices in these areas, as based on her/his opinion, not all the improvement

activities should be documented. Other lecturers said that no documentation is done because there is no policy that required that, and he or she is not aware if this documentation will be used or shared with the others for further benefits. Another argument against documentation was that lecturers do not have time to do a documentation. Documentation should be considered only in shared laboratory courses as then it can be shared with the colleagues.

Apart from looking closer at the process areas, there has been a set of suggestions to improve the set of practices. In some sense, we see this as practices, that school teachers can now learn from university teachers.

- One interviewee suggested to include student feedback (as it is collected twice a semester in Klagenfurt) as a practice in the TeaM model. The feedback should then be analyzed and taken into consideration during the lecture.
- A lecturer suggested to add a practice where teachers use an anonymous forum to collect questions.
- On a goal level, it was suggested to add a subprocess for motivating and activating inactive students.

According to the questions dealing with practices and goals, TeaM model got also some useful comments: First, the TeaM model should consider the different types of lectures (seminar, lecture, lab, etc.) as some of the goals might then be obsolete or more important. Secondly, there should not just be "Yes/No" answers. Next, it was suggested to avoid longer questions (so breaking sentences apart). Finally, it was advised to not just stick to Google-Forms interviews, but also make use of an instructor (assessor) leading through the evaluation.

In all, acceptability was satisfying. The lecturers implemented quite some of the practices, but they were never thinking about some relation between them and that all of them are important for the teaching process as a whole. Have a TeaM model assessment now already had a positive impact on them as they started to think more about the quality of teaching and the use of standards to help them managing that quality.

Discussions

For answering the question about the (number of) differences in teaching practices between university and school teachers, all the different part of the teaching process, step-by-step were controlled. The suggestions and comments received during the questionnaire allow us to tell more about the commonalities and differences. The practices related to *documentation* aspects were the largest problem for university lecturers and they tried to argue why such practices were not to be implemented.

From the perspective of school teachers, we still see documentation as something important and necessary. On the other side, university teachers are quite open-minded to be evaluated, something that is harder to be found in the school setting [RB18b].

Another difference between school and university teachers is to be found in SG2.4. There, *incident management* is not seen as something important by university teachers. Identification and resolution of incidents is only dealt with when required. This is, due to a different setting, handled different in the case of school teachers, where teachers, members of the rectorate and/or in the best case also psychotherapists work together to prevent or resolve incidents in classes [RB18b].

Another difference can be found in SG4.1, where the *observation of the teaching process* is seen as not so significant by university teachers. Quite often the only feedback they get is by looking closer to the students' results and the students' feedback at the end of the semester. This is contrary to schools teachers, where the continuous observation is related to class improvements and also pupils motivations. A partial difference is also shown in SG4.2, where the absence of the *reflection over the teaching process* is observed. From the perspective of schools teachers, this is a practice that always needs special consideration and university teachers could learn a lot from it [RB18b].

Finally, a small difference is to be found in SG2.3, *methodology selection*, and in its *improvement* in SG4.3. Choosing suitable methodologies is important for schools teachers, but the same holds not for university teachers [RB18b].

To summarize, only 12 out of 31 goals are nearly completely met by university teachers. 9 goals are at least partially fulfilled. The university teachers are weak in the aspects of documentation, incident management, teaching process observation and reflection. But they are strong in the areas of commitments, dealing with resources, discovering needs, designing course objectives and in content planning [RB18b].

Threads of Validity

In this research there might be some threats to the validity. For its implementation, it was tried to avoid any bias by selecting different informatics lectures at our university, choosing lectures from different fields of informatics study, and also of different characteristics. However, the results are restricted to our university and might not be generalizable to other universities [RB18b].

The questionnaire remained the same until the last lecturer was interviewed. The research duration was no more than three weeks, and the participant did not have the possibility to evolve their ways of teaching in-between. However, it can not be guaranteed that some of them had the chance to speak to each other, influencing the results. The participation in the questionnaire was voluntary, and it is assumed

that the answers were correct. But,it is not guaranteed that the interviewees were honest in their answers, even though that it is believed so, as their answers had no influence on their reputation [RB18b].

This TeaM questionnaire helped on having clear the differences between university and schools teachers. Although the goals and practices of the TeaM model were mostly defined by the schools teaches, the results from this research defined that, no important PAs or goals were missing in the model. For this reason, the same questionnaire was used to check the usability and applicability of the TeaM model in the university context (explaned in detailed in Section 4.3.2). The results would, later on, help to define if university teachers are willing to use the TeaM model for assessing the quality of teaching in their courses and, if yes, what will be the results by applying TeaM in practice (Section 4.3.3).

4.3.2 Usability and Applicability of TeaM in University Context

The creation of the TeaM model is associated with the question of how to integrate it in a daily teaching life, so teachers can use it for assessing the quality of their lectures. This means to test and improve the model based on their feedback. Within this, it was possible to test its usability and acceptability in practice. The objective now was to evaluate the applicability of TeaM (in terms of the two aforementioned properties usability and acceptability) with informatics lectures at Universität Klagenfurt [RB18a]. In this context the following question was to be answered [RB18a]:

- How is the applicability of the TeaM model perceived by lecturers at the Universität Klagenfurt?

To deal with the objective and for answering the question, a structured interview accompanied by a questionnaire was performed [RB18a].

Settings

To assess the applicability of the TeaM in practice, a survey (including questionnaire and interviews) was used as a research instrument. The form of the assessment was planned in a similar way to CMMI appraisals [RB18a].

Firstly, potential lectures and lecturers at Universität Klagenfurt were identified. 30 informatics courses from bachelor and master programs were randomly selected. The experimental subjects were the lecturers of these courses who were then interviewed. From 30 informatics courses that were selected, only 13 lecturers participated and answered the questionnaire. The lecturers varied in their experience in teaching, from 3 years to 25 years. Only one lecturer was female, but all of them were specialized in the field of informatics and are teaching in the bachelor and master programs [RB18a].

The 76 practices of the TeaM model were considered and a catalog with questions was provided. The catalog contained 76 "yes/no" questions representing the 76 practices. For instance, the practice "SP1.2.1.2 Arrange the Classroom Atmosphere" is mapped to the questionnaire as the question (translated to English): "7. Do you attempt to provide an adequate atmosphere in the classroom?" The same strategy was applied to all the other practices [RB18a].

For supporting the appraisal process, the 76 questions were provided in an electronic format using Google forms (similarly as in the previous research, and accessible in this link [Que18]).

For performing the appraisal, two non-expert assessors (members from the Informatics Didactic Department of the Universität Klagenfurt) were involved in the interviews. During the interviews, the teachers were given two questionnaires. The first questionnaire contained 76 questions related to 76 practices of the TeaM. This was necessary in order to introduce the model to the teachers (by applying it in practice). The second questionnaire (with 7 questions) focused on the two dimensions, usability and acceptability, and it was given to teachers after applying the TeaM model. The questions focused on [RB18a]:

- (Q1) Time to fill out the TeaM questionnaire
- (Q2) The understandability of the questions
- (Q3) How much they liked filling out the questionnaire
- (Q4) The assumed benefit of the model in the future
- (Q5) The relevance of the model for assessing the quality of teaching
- (Q6) Whether the model would criticize the teachers' way of teaching
- (Q7) Other observations or ideas to share

Results

The 13 lecturers participating in the questionnaire, firstly answered the 76 "yes/no" questions about the practices of the TeaM model to provide their opinion about missing/relevant practices (explained already in Section 4.3.1). Secondly, they were asked to fill in the questionnaire with 7 questions (scope of this study) to better understand their perceptions about usability and acceptability of the model. After analyzing the outcomes from the 7 questions, the results are as follow [RB18a]:

(Q1) The first question was related to the time required to fill out the questionnaire. The average time was 30 minutes to answer the 76 questions. Only one

interview lasted longer (56 minutes) because the assessor read the questions and the interviewee read the questions himself one more time.

(Q2) The second question dealt with the understandability of the questions from the first questionnaire. We were looking for any ambiguities. Five questions needed explanation from the assessor, because their structure was misleading for the interviewees. Basically, these questions were connected with "and/or" conjunctions and they confused the interviewees. Examples of such questions were: "Do you consider other requirements that might come from students/pupils (like explanation of a new term, repetition of an exercise, etc.), OR administration (like substituting a colleague in one teaching hour because she/he is sick?)"; "Do you consider AND document problems during units' delivery?" Another problem was a set of questions related to existing curricula. As there are courses which are not based on only one curriculum, a correct answer was impeded as well.

(Q3) The third question produced a ranking from unpleasant (1) to wonderful (10) of the process for filling out the questionnaire. The interviewees rated it with 6. This was related to the unclear structure of the sentences and due to the fact that they had to think about their teaching process for the first time. This created a little tension for them and they were trying to explain the reason why their answers were "no" or why "bad" things happened in their course. The assessors think that the TeaM questionnaire might work better without the presence of an assessor. However, the interviewees expressed their deep interest in the model.

(Q4) The benefit in using this model for the future was the fourth question. The interviewees liked the idea of thinking about the questions that helped to improve their teaching, so they thought that it was an advantage to use the model. The only problem identified was related to documentation practices that were required by the model.

(Q5) The fifth question revealed if the TeaM is relevant or appropriate to be used in order to assess the quality of teaching. None of interviewees raised a concern that any of the questions was not related to the quality of teaching. They saw it as a good collection of standards to follow for addressing the quality.

(Q6) The sixth question looked closer at the fear of the interviewees if such an assessment could criticize their way of teaching. In a way, the answers were "yes". They expressed this response even in question 3. There, they expressed worries about some questions that they could only answer with "no", and this was in a major way related to the documentation practices.

(Q7) Last but not least, they were asked about other observations or ideas to share. They thought that providing more information on the questions in such a way that no assessor had to participate during the assessment would make them answer with less tension. Most questions were well understandable and also interesting to think about. Already the process of trying to answer the questions and thinking of their own process was felt to be worthwhile.

Discussions

The applicability in practice of the model somehow surprised the teachers and made them think of teaching as a process (maybe for the first time). Considering the CMMI appraisal catalog, TeaM takes much less time for answering the questions (referring to Q1). This is worthwhile when thinking about the model as a part of assessing and improving your work.

The results from (Q2), suggested some improvements of the TeaM regarding the structure of its "and/or" sentences. They proposed to split this type of questions even though their splitting will yield to a slightly larger number of questions, and consequently to a higher time consumption. However their suggestions were taken in consideration, and now the last verion 0.9 of the TeaM model contain separated "and/or" sentences [RB19a].

Considering the main question related to the objective of this paper, and the study results, it is stated that the TeaM model seems interesting from the general point of view of the lecturers at Universität Klagenfurt [RB18a]. A version of the model with clearer questions and no assessor will motivate the teachers to further use it in the future. This study demonstrate the applicability of the model by the teachers at Universität Klagenfurt. Another benefit to be considered is: the idea that teachers started thinking about their teaching process in detail. When perceiving TeaM more as a self-assessment framework rather than as a raking generator, then its integration in practice in the educational domain could be greater [RB18a].

Threads of Validity

In this research there might be some factors contributing to the results. In order to avoid any bias, for the implementation different lecturers with different characteristics and teaching objectives were selected. However, the results are restricted to Universität Klagenfurt and they do not present a generalization from other universities [RB18a]. Applying TeaM in other universities is addressed in a future study.

Both questionnaires (introducing TeaM model and testing its applicability in practice) remained the same until the last lecturer was interviewed. Due to the fact that these interviews do not influence the personal reputation of any participant, it is hoped that the answers were honest, but this is something not to be guaranteed.

The research duration was about 3 weeks, assuming that this period was not enough for teachers to further evolve their ways of teaching.

Last but not least, it cannot be guaranteed, but it is assumed that the teachers did not influence the results by talking to each other as they came from different institutions of Informatics at Universität Klagenfurt, and as the research duration was relatively short.

Knowing that TeaM model was considerably accepted by university teachers at

Universität Klagenfurt, then, the next section demonstrates the results of the quality of teaching by applying this model in some informatics courses at this university.

4.3.3 TeaM Evaluation in the University Context

Creating the TeaM model, controlling if any goal or practice is missing by the university teachers side, and testing its applicability helped to come up with a stable version of the model. Now this research makes use of the TeaM model as an assessment tool to address the quality of teaching in the university context.

The quality of teaching indicates a) the learners' satisfactions, b) the learning outcomes and c) the consistency of best practices of teachers (defined in Section 2.2). In this research, by applying the TeaM model in Universität Klagenfurt, only two aspects of the quality (a and c) are considered [RB19b]. For this scope, 19 informatics courses at this university are selected. The students enrolled in these courses have the possibility to provide feedback, and this is electronically stored in a system called ZEUS.

The question now is, if the Teaching Maturity model really addresses the quality of teaching for these two aspects. For that, a statistical comparison between the results from applying the TeaM model in the 19 informatics courses and the students' feedback (ZEUS) for these courses is evaluated. All the practices of PAs implemented by the university teachers (referring to a) and at the students' perspective (referring to c) are controlled [RB19b].

So, within the scope of the research in this thesis, the following two questions are raised [RB19b]:

- Are all the process areas suitable for teachers at Universität Klagenfurt?
- To what extend are the results from the Maturity Level and students perception of the course correlated?

An important issue in this research was to learn from the results with the aim to further improve the TeaM model. For doing that, was checked if a regrouping of PAs into MLs was necessary and if there are certain correlation between PAs that need additionally revision [RB19b].

Each task of the research is presented graphically in Figure 4.1, in the second part named *Team Evaluation in University*. Keeping in mind the TeaM structure, the practices of the model are presented in form of a questionnaire. The courses were randomly selected, and the questionnaire was used during the interviews with the teachers of these courses. All the feedback was collected and analyzed. Reflection on the results contributed to the improvement of the model and to the creation of a TeaM Website.

Settings

For conducting the research the same questionnaire, explained in Section 4.3.1, and accessible in this link [Que18], was used. Each practice of the TeaM model was presented in a form of a question. There were 76 "Yes/No" questions corresponding to the 76 practices of the model. These questions were answered only by university teachers.

A total of 19 informatics courses from the Bachelor and Master program at the Universität Klagenfurt were randomly selected. They were of a variety of types of classes like seminar, selected topics, labs, tutorials, etc. The correspondent teachers of these 19 courses were lectures and assistant teachers.

At the same time, with the help of the ZEUS system, the students' feedback for each of these courses was collected. The assessment of these courses with the TeaM model was applied only once and at the end of the course [RB19b].

The ZEUS system defines the level of satisfactions that students have for a specific course. It is composed of 6 fixed questions, and provides the opportunity to add supplementary questions from teachers. Within this, 4 questions have the possibility to be answered in a range of evaluation from "very good" to "no response". The questions deal with the reason why students attend the course, the progress students make, the overall evaluation of the course, and the equality of treatment between students by their teachers. The 2 remaining questions are text field leaving some space for students to provide suggestions for course improvement [RB19b].

The TeaM questionnaire was distributed to the lecturers of these courses. Three interviewees, all of them members of the department of informatics didactics in Klagenfurt, helped to do the TeaM appraisal for the courses. The questions were answered by the teachers, but beyond the "Yes/No", they were free to give additionally free-text answers, which were recorded and used for later analysis. The duration of each interview was 30 to 40 minutes. Everything was electronically documented. The fifth task of this second step was the analysis of the collected data from the interviews. The implementation of 76 questions (practices) was calculated to determine if the goals of the model were fulfilled. The calculations followed the CMMI principle of appraisal, meaning that, in our situation, 80% of the questions should have been answered with "Yes". From this derived the determination if and which goals are achieved. The same strategy was applied to goals to see which PAs are satisfied. This means 80% of goals related to a PA should have been achieved. The satisfaction of a group of PAs established the Maturity Level for each course [RB19b].

Within the scope of this contribution four statistical tests were used to assess the selected data. First, the normal distribution of data was controlled. The Anderson-Darling normality test was used for this purpose [TH08]. Secondly, the Pearson's Correlation Coefficient, the Spearman's Correlation Coefficient and the Kendall's

Correlation Coefficient were applied to the data. And finally, a regression analysis (Backward Elimination) was conducted to define which PAs are statistically significant and contribute to the model [RB19b].

Statistical procedures (as the one we have used) require to assess the assumption of normality. The violation of the normal assumption leads to the invalidity of the interpretation and inferences. In this study we use the Anderson-Darling normality test [TH08].

The Pearson's correlation coefficient Rho (Rp) looks only on a linear correlation between the variables. It measures the degree of association between them [Ree00]. Pearson's correlation assumes a normal distribution of the values. The test works even when the data are not normally distributed, but it looks only on the linear correlation. The results might indicate no correlation if the data is correlated in a nonlinear manner.

To handle the cases when the data is not normally distributed, the Spearman's rank correlation coefficient Rho (Rs) is used [Ree00]. It is a non-parametric version of Pearson, and uses a monotonic function to describe the correlation between variables. The sample data are ranked separately for each variable and then the correlation is defined.

An alternative of the Spearman's test is the Kendall correlation coefficient Rho (Rk) [NP+97]. It is also a non-parametric test and defines the relation among pairs of data. The data is ranked relatively and partial correlation is possible to be detected.

For this research, the correlation coefficient is explained as follows [RB19b]:

- When Rho is between [0.7, 1.0], the correlation is interpreted as strong relation.
- When Rho is between [0.4, 0.7), the correlation is interpreted as medium relation.
- When Rho is between [0.0, 0.4), the correlation is interpreted as weak relation.

In the interpretation of the results, besides the above values, the significance value (p) of the null hypothesis is considered. The null hypothesis aims at showing that there is no statistical evidence between the variables. The p-value is been defined equal to 0.05 and any probability of the value Rho smaller or equal to p-value indicates stronger evidence against the null hypothesis [RB19b].

The p-value is used also to interpret the results from the regression analysis in the backward elimination [YL06]. The regression analysis defines which from the independent variables are related to the dependent variable. It explores the best equation that a set of data matches the linear regression line. The backward elimination enters all the independent variable to the equation and eliminates once a time those that have a bigger value than the significant value (p).

Results

This second step of the research for this thesis [RB19b] provided the below results:

Firstly, for presenting the relation between Maturity Levels and the ZEUS grades a scatter plot (see Figure 4.4) was produced. This helped to get a first feeling about possible relations and differences between them. On the y-axis are the ZEUS grades on a scale from 1 to 5, where, according to the Austrian grading system, 1 means the highest achievement. The linear trend-line in Figure 4.4 indicates a slightly decreasing linear line between the ZEUS grades and the Maturity Level. In other words, the higher the Maturity Level is, the lower is the ZEUS grade, which means that the students were more satisfied [RB19b].

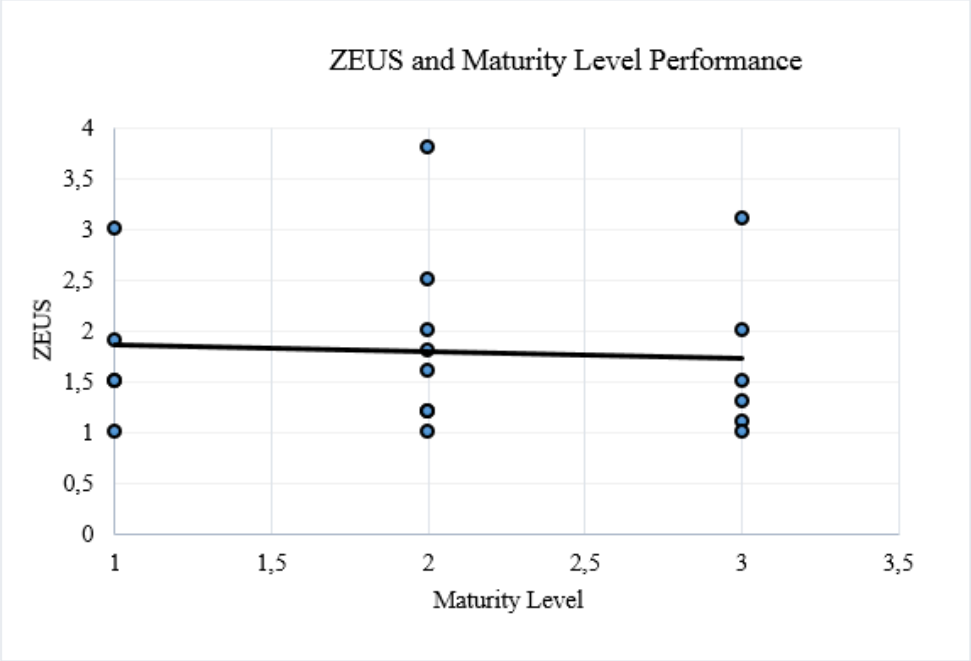

Fig. 4.4: Scatter-plot for visualizing the relation between the Maturity Levels and the ZEUS feedback. The Maturity Level ranges from 1 to 5 but no course reached levels 4 or 5, so it is not presented in the figure [RB19b].

The Scatter plot was useful for getting a first feeling, but there are quite some data points spread away from the trend-line. A statistical test is required for their interpretation. The ML is strongly related with the PAs. During the statistical tests, the 12 PAs of the TeaM model have been always considered as variables. The null hypothesis in the Anderson-Darling test assumes that the variable from which the sample was extracted follows a normal distribution. For every A-square value of the test which is smaller than the p-value, the null hypothesis is rejected. Considering

Variable\Test	Anderson-Darling
P1.2 Availability of Resouces (AR)	**< 0,0001**
P2.1 Design Objectives (DO)	**< 0,0001**
P2.2 Content Planning (CP)	**0,385**
P3.1 Delivery and Consolidation (DC)	**< 0,0001**
P3.2 Assessment Management (AM)	**< 0,0001**
P1.1 Determining Commitment (DCOM)	**0,001**
P1.3 Discovering Needs (DN)	**< 0,0001**
P2.4 Incident Management (IM)	**0,002**
P2.3 Methodology Selection (MS)	**0,025**
P4.1 Observing the Teaching Process (OTP)	**0,096**
P4.2 Reflecting on the Teaching Process (RTP)	**0,004**
P4.3 Improve Teaching (IMT)	**0,092**
Maturity Level	**0,001**
ZEUS	**0,015**

Fig. 4.5: The Anderson-Darling normality test for the 12 PAs.

the results from the Anderson-Darling's test (see Figure 4.5), P2.2 Content Planning has a mean of 0.731 and a standard deviation of 0.161. Due to the p-value (0.385) the null hypothesis is rejected, meaning that this PA is normally distributed. P4.1 Observing the Teaching Process is also normally distributed due to the p-value (0.0957). It has a mean of 0.538 and a standard deviation of 0.197. The last distributed PA is P4.3 Improve Teaching (p-value (0.092)) with a mean of 0.598 and a standard deviation of 0.192 [RB19b].

For finding a correlation between the set of variables (PAs, ML and ZEUS), statistical tests (Pearson, Spearman and Kendall) where applied (see Figures 4.6, 4.7, 4.8). The Rho-values marked bold have a p-value smaller then 0.05. This means that the null hypothesis is rejected and that the Rho-values show some statistical evidence between the variables. The other Rho-values (not marked) have a p-value bigger then 0.05 and have to be interpreted with care. This research focused and considered only those Rho-values that have statistical evidence.

Following the objective of this research, the relation between ZEUS grades and the Maturity Level ML (including its PAs) was of importance. When looking at Pearson's results, there is only one relation, the positive medium relation between the ZEUS grades and P2.2 Content Planning (0.491). The results detail information concerning the relation PAs and ML. The Maturity Level has a positive strong correlation with P1.3 Discovering Needs (0.691), P2.4 Incident Management (0.815),

P4.1 Observing the Teaching Process (0.851) and P4.3 Improve Teaching (0.671). Furthermore, Maturity Level has a positive medium relation with P2.1 Design Objectives, P3.1 Delivery and Consolidation, P1.1 Determining Commitment, and P4.2 Reflecting on the Teaching Process. The rest of the PAs have a weak relation with the ML [RB19b].

Pearson Rho	P1.2	P2.1	P2.2	P3.1	P3.2	P1.1	P1.3	P2.4	P2.3	P4.1	P4.2	P4.3	ML	ZEUS
P1.2 Availability of Resouces (AR)	1,000	**0,714**	-0,033	**0,508**	0,072	-0,039	0,323	0,265	0,260	0,419	0,406	0,342	0,424	0,307
P2.1 Design Objectives (DO)		1,000	0,150	0,294	0,300	0,159	**0,473**	0,337	0,396	**0,485**	0,290	0,260	**0,622**	0,115
P2.2 Content Planning (CP)			1,000	0,042	0,054	-0,374	0,134	-0,042	0,394	0,013	-0,399	0,331	0,021	**0,491**
P3.1 Delivery and Consolidation (D				1,000	0,037	0,044	**0,471**	0,415	0,347	0,441	0,447	**0,762**	**0,543**	0,231
P3.2 Assessment Management (AN					1,000	0,162	0,107	-0,065	0,283	0,240	0,065	0,144	0,233	-0,175
P1.1 Determining Commitment (DC						1,000	0,259	**0,502**	0,121	0,436	**0,489**	0,292	**0,511**	-0,067
P1.3 Discovering Needs (DN)							1,000	**0,743**	0,117	**0,555**	**0,512**	**0,507**	**0,691**	0,161
P2.4 Incident Management (IM)								1,000	-0,072	**0,731**	**0,686**	**0,559**	**0,815**	0,141
P2.3 Methodology Selection (MS)									1,000	0,047	-0,115	0,430	0,174	0,385
P4.1 Observing the Teaching Proce										1,000	**0,487**	**0,597**	**0,851**	-0,115
P4.2 Reflecting on the Teaching Prc											1,000	0,405	**0,607**	0,112
P4.3 Improve Teaching (IMT)												1,000	**0,671**	0,317
Maturity Level													1,000	-0,062
ZEUS														1,000

Fig. 4.6: Pearson Rho for the 12 PAs, ML and ZEUS grades. The results marked bold have a p-value smaller then 0.05 and indicate a correlation between variables. (n=14)

Spearman Rho	P1.2	P2.1	P2.2	P3.1	P3.2	P1.1	P1.3	P2.4	P2.3	P4.1	P4.2	P4.3	ML	ZEUS
P1.2 Availability of Resouces (AR)	1,000	**0,542**	-0,004	**0,474**	0,156	0,109	0,133	0,231	0,211	0,436	0,452	0,408	0,381	0,251
P2.1 Design Objectives (DO)		1,000	0,197	0,212	0,345	0,209	0,310	0,266	0,315	0,437	0,288	0,281	**0,566**	0,068
P2.2 Content Planning (CP)			1,000	0,177	0,097	-0,426	0,096	-0,040	0,291	0,005	-0,334	0,418	0,056	**0,683**
P3.1 Delivery and Consolidation (D				1,000	0,019	-0,024	**0,474**	**0,520**	0,266	0,452	0,429	**0,686**	**0,538**	0,343
P3.2 Assessment Management (AN					1,000	0,068	0,193	-0,083	**0,528**	0,232	0,054	0,221	0,223	-0,080
P1.1 Determining Commitment (DC						1,000	0,384	0,457	0,109	**0,469**	**0,461**	0,231	**0,509**	-0,214
P1.3 Discovering Needs (DN)							1,000	**0,766**	0,144	**0,616**	**0,509**	**0,642**	**0,736**	0,054
P2.4 Incident Management (IM)								1,000	-0,103	**0,718**	**0,615**	**0,664**	**0,767**	0,148
P2.3 Methodology Selection (MS)									1,000	0,063	-0,164	0,397	0,147	0,350
P4.1 Observing the Teaching Proce										1,000	**0,508**	**0,626**	**0,862**	-0,056
P4.2 Reflecting on the Teaching Prc											1,000	0,439	**0,619**	-0,165
P4.3 Improve Teaching (IMT)												1,000	**0,680**	0,452
Maturity Level													1,000	-0,072
ZEUS														1,000

Fig. 4.7: Spearman Rho for the 12 PAs, ML and ZEUS grades. The results marked bold have a p-value smaller then 0.05 and indicate a correlation between variables. (n=14) [RB19b]

The Spearman's correlation coefficient test is recommended in situations when the variables are not normally distributed, and there is a nonlinear relation. The results are shown in Figure 4.7. Unlike the Perason test, the Spearman test shows that there is a positive strong relation between the ZEUS grades and P2.2 Content Planning (0.683). When looking at the correlation between ML and the PAs, we noticed that the Maturity Level has a positive strong relation with the P2.4 Incident Management (0.767), P4.1 Observing the Teaching Process (0.862), P1.3 Discovering Needs (0.736) and P4.3 Improve Teaching (0.680). On the other side there is a

Kendall Rho	P1.2	P2.1	P2.2	P3.1	P3.2	P1.1	P1.3	P2.4	P2.3	P4.1	P4.2	P4.3	ML	ZEUS
P1.2 Availability of Resouces (AR)	1,000	**0,519**	0,000	**0,449**	0,141	0,100	0,128	0,205	0,177	0,382	0,398	0,338	0,353	0,214
P2.1 Design Objectives (DO)		1,000	0,165	0,203	0,302	0,188	0,295	0,230	0,271	0,336	0,243	0,245	**0,502**	0,041
P2.2 Content Planning (CP)			1,000	0,135	0,080	-0,340	0,077	-0,033	0,197	0,006	-0,237	0,325	0,051	**0,506**
P3.1 Delivery and Consolidation (D				1,000	0,021	-0,031	0,432	**0,433**	0,209	0,403	0,391	**0,577**	**0,504**	0,268
P3.2 Assessment Management (AN					1,000	0,058	0,171	-0,071	**0,433**	0,198	0,056	0,166	0,197	-0,051
P1.1 Determining Commitment (DC						1,000	0,358	**0,433**	0,097	**0,391**	0,385	0,161	**0,463**	-0,190
P1.3 Discovering Needs (DN)							1,000	**0,690**	0,121	**0,519**	**0,441**	**0,529**	**0,671**	0,061
P2.4 Incident Management (IM)								1,000	-0,070	**0,597**	**0,442**	**0,513**	**0,669**	0,126
P2.3 Methodology Selection (MS)									1,000	0,034	-0,121	0,279	0,115	0,268
P4.1 Observing the Teaching Proce										1,000	**0,381**	**0,506**	**0,787**	-0,045
P4.2 Reflecting on the Teaching Pr											1,000	0,307	**0,505**	-0,154
P4.3 Improve Teaching (IMT)												1,000	**0,580**	0,323
Maturity Level													1,000	-0,058
ZEUS														1,000

Fig. 4.8: Kendall Rho for the 12 PAs, ML and ZEUS grades. The results marked bold have a p-value smaller then 0.05 and indicate a correlation between variables. (n=14)

positive medium relation of ML with P2.1 Design Objectives (0.566), P3.1 Delivery and Consolidation (0.538), P1.1 Determining Commitment (0.509) and P4.2 Reflecting on the Teaching Process (0.619). The rest of the PAs have a weak relation with the ML [RB19b].

The Spearman's test demonstrates also the relation between all the PAs. We found a medium relation of P3.1 Delivery and Consolidation from ML 2 with 2 PAs at ML 3 (P1.3 Discovering Needs, P2.4 Incident Management) and a strong relation with a PA from ML 5 (P4.3 Improve Teaching). A medium correlation of P3.2 Assessment Management from ML 1 with P2.3 Methodology Selection from ML 4 was observed. P1.3 Discovering Needs (from ML 3) has a medium correlation with P4.1 Observing the Teaching Process (ML 4), with P4.2 Reflecting on the Teaching Process and with P4.3 Improve Teaching ML(5). A medium correlation is found between the P1.1 Determining Commitment from ML 2 with P4.1 Observing the Teaching Process (ML 4) and with P4.2 Reflecting on the Teaching Process (ML 5). P2.4 Incident Management (from ML 3) has a strong correlation with P4.1 Observing the Teaching Process (ML4) but a medium correlation with P4.2 Reflecting on the Teaching Process and with P4.3 Improve Teaching (ML 5). Finally, P4.1 Observing the Teaching Process (ML 4) has a medium correlation with P4.2 Reflecting on the Teaching Process and with P4.3 Improve Teaching (ML 5).

A Kendall test was analyzed as well. The test was used to check for nonlinear partial relations. Unlike Spearman, but like Pearson, Kendall's test shows a positive medium relation between ZEUS grades and P2.2 Content Planning (0.506). This test (similar to Pearson and Spearman) confirms once again that there is only one relation between ZEUS and PAs [RB19b]. While examining the relation ML and PAs, the results from this test reveal that there are strong relation of ML with P4.1 Observing the Teaching Process (0.787), P2.4 Incident Management (0.669) and P1.3 Discovering Needs (0.671). Some medium relation are found between the ML and P2.1 Design Objectives (0.502), P3.1 Delivery and Consolidation (0.504), P1.1

Determining Commitment (0.468), P4.2 Reflecting on the Teaching Process (0.505) and P4.3 Improve Teaching (0.580). The rest of the PAs have a weak relation with the ML [RB19b].

$$y = a + bx \tag{4.1}$$

$$a = \frac{\left(\sum y\right)\left(\sum x^2\right) - \left(\sum x\right)\left(\sum xy\right)}{n\left(\sum x^2\right) - \left(\sum x\right)^2} \tag{4.2}$$

$$b = \frac{\left(\sum xy\right) - \left(\sum x\right)\left(\sum y\right)}{n\left(\sum x^2\right) - \left(\sum x\right)^2} \tag{4.3}$$

It was wondered which PAs contribute to the model. For this reason a regression analysis using a backward elimination algorithm was performed (see Figure 4.9). The 12 PAs, formed the independent variables, and those with the highest p-value (always considered those with p-value bigger then 0.05) were eliminated. The dependent variable was the ZEUS grade. In the equation 4.1, b is the slope of the line (equation 4.3) and a is the y-intercept (equation 4.2). The results from the test demonstrated that only P2.2 Content Planning is of statistically significance in the model, something expected seeing the results from the other tests performed earlier. It has a medium correlation of 0.491 and it shows that 24% of all the variation of ZEUS-values are explained by the independent variable P2.2 Content Planning [RB19b].

Regression Statistics	
Multiple R	0,491
R Square	0,241
Adjusted R Square	0,197
Standard Error	0,713
Observations	19,000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2,751	2,751	5,410	0,033
Residual	17	8,646	0,509		
Total	18	11,398			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,005	0,785	0,006	0,995	-1,651	1,660	-1,651	1,660
P2.2 Content Planning	2,441	1,049	2,326	0,033	0,227	4,654	0,227	4,654

Fig. 4.9: P2.2 Content Planning defined from the Backward Elimination as the only independent variable related to ZEUS grades. (n=13)

Finding the correlation of PAs with the ML-s and how they can be rearranged in ML was also of interest. The results of the study suggested that the split of PAs into

Maturity Level should be changed. Four changes were applied in the reconstruction of MLs. The PA Methodology Selection was moved from ML 2 to ML 4. Determining Commitment changed the ML from 3 to 2. Observing te teaching Process moved to ML4 and finally, Reflecting on the Teaching Process was shift to ML5. Basically, the revised version of ML is now presented in Table 3.3 [RB19b].

Discussions

For answering the two questions raised in the second step of the research in this thesis, all the possible variables were considered. It was looked in details which of them contribute to the TeaM model. The results were somehow expected. In contrast to the TeaM model, ZEUS focuses on one aspect of the quality of teaching (that of students' motivation and satisfaction). The assessment is generated based on the students' perception. On the other hand, the TeaM model considered all the processes that influence the quality of teaching and the assessment relies on standards, avoiding personal feedback [RB19b].

When considering the results from the three tests (Pearson, Spearman, Kendall), it is noticeable that there are some similarities and differences between them. A difference is seen in the relation ZEUS - PAs, where, unlike Pearson and Kendall, Spearman suggests a strong relation of the ZEUS grades and P2.2 Content Planning Process Area. The correlation values of the three tests differs slightly, but the Spearman' result is closer to that of Kendall. However, the three of them confirm that the Maturity model is appropriate in the context of university teaching when at least one Process Area is considered. This means that at Universität Klagenfurt teachers pay attention only to the process for planning the course content. The result is reinforced also by the regression analysis. In Austria, University teachers also have to publish a lot. So it is assumed that in such setting they put more efforts in their research then on teaching [RB19b].

Differences are to be found also in the relations of PAs between them. The Pearson test presents a medium correlation between P2.1 Design Objectives and P1.3 Discovering Needs. Such a relation is not presented neither in the Spearman test, nor in Kendall test. Logically, this relation should make sense as the discovered learners' needs should be taken into account while designing the course objectives. Similar, the relation P3.1 Delivery and Consolidation and P1.3 Discovering Needs is treated by Pearson and Spearman, but not by Kendall. Also here, the learners' needs should be considered when delivering and consolidating the teaching units [RB19b].

Quite a surprising relation is that of P1.1 Determining Commitment and P2.4 Incident Management. The relation is of medium strength in the Pearson and Kendall tests. Actually, it is somehow difficult to understand how the management of incidents might influence the duties of stakeholders included in the teaching process. On

the other side it is natural that one of the duties of a teacher is also to be prepared for the incident [RB19b].

The Pearson test shows a medium correlation between P2.1 Design Objectives and P4.1 Observing the Teaching Process: such a correlation is not at all in Spearman and Kendall tests. This relation is important as the results by the observation of the teaching process will be considered next time when defining the objectives of the course [RB19b].

Pearson and Spearman tests show a strong correlation between P3.1 Delivery and Consolidation and P4.3 Improve teaching, but in the Kendall test this correlation is of a medium strength. Considering the educational domain, it makes sense that such a relation is strong as changes on improving teaching mean also changes on improving delivery and consolidation [RB19b].

Threads of Validity

There are many factors contributing to the results. Defining the correlation of ZEUS with ML was in a certain level difficult. First, the number of questions in TeaM (76) where considerable in respect to ZEUS (6). Secondly, the interviewees come from two different domains. ZEUS results are generated by students and the results might not have been given objectively. The TeaM questionnaire was answered by teachers and we assume them being honest, as no ranking was produced. Finally, the questions in ZEUS are only related to satisfaction level for a course. The other areas of teaching process are not considered.

Another factor that might have influenced the results was the number of participants (19 in total).

Last but not least, the answer form might have had an effect. Only "Yes/No" answers limited the interviewee, and we noticed that they were sometimes confused by the questioning. Future evaluations now rely on a 6-type scale answers defined in the TeaM app [RB19a].

Apart from that, for the implementation of the study, it was tried to avoid any bias by selecting different informatics lectures at Universität Klagenfurt, choosing lectures from different fields of study, and also of different characteristics. However, it cannot be guarantee that some of the interviewees had the chance to speak to each other, influencing the results. The same interviewees were used throughout the study. The questionnaire remained the same until the last lecturer was interviewed. The study duration was no more than three weeks, and the participant did not have the possibility to evolve their ways of teaching in-between. The participation in the questionnaire was voluntary.

Finally, the results are restricted to Universität Klagenfurt and might not be generalizable to other universities.

The second step of the research in this thesis demonstrated the applicability

of the TeaM model at Universität Klagenfurt and helped in improving TeaM by providing TeaM v0.9. The third step demonstrates the evaluation of the TeaM model in school.

4.4 TeaM Assessment in Schools

Investigating if the Teaching Maturity model addresses the quality of teaching in schools was the last step of the thesis. Considering the definition in Section 2.2, the quality of teaching indicates a) the consistency of best practices of teachers, b) the learning outcomes, and c) the learners' satisfaction . In this research, only two aspects of the quality (b and c) are considered. For this, four schools in Carinthia, with a total of 8 courses, were selected. The learners enrolled in these courses could provide feedback about their satisfaction and the efficiency in which the teaching process enables them to obtain the knowledge.

So, within the scope of the research in this thesis, the following two questions are raised:

- Are all the process areas suitable for teachers at schools in Carinthia?
- To what extend are the results from the Maturity Level and learners' perception of the course correlated?

An important issue was to learn from the results to improve the TeaM model further. For doing that, was checked if a regrouping of PAs into MLs was necessary and if there are specific correlation between PAs that need additional revision.

Each task of the research is presented graphically in Figure 4.1, in the third part named *Team Evaluation in Schools*. As a first task, the TeaM Website app was created. The second step of the research (TeaM evaluation in University) helped in polishing the TeaM model. The redefined version of the model was implemented in such a way to provide a self-assessment platform [1]. As a next task, there was a random selection of courses and to the related teachers. The teachers answered the TeaM model's questions, and pupils the questions concerning learners' satisfaction and outcomes. All the feedback was collected and analyzed. Reflection on the results contributed to the improvement of the model.

4.4.1 Study Settings

Four schools in Carinthia participated in this research. In the survey, four teachers were engaged, with a total of 8 classes. Two classes (grade 3 and 4) of elementary school (Volkschule Klasse 3 and 4), five classes (grade 1 to 4) of secondary school

[1] TeaM Evaluation Website (https://team-iid.aau.at/welcome).

(Secondarschule I - Mittelschuche/Gymnasium Klasse 1-4), and one class (grade 2) of secondary schools II (Gymnasium Klasse 6). The pupils' age varies from 9 to 16 years old, and from 163 pupils, only 130 took the survey. One of the teachers was an elementary school teacher, who teaches mathematics, German, English, technical work, visual education, and factual education. The other three teachers teach informatics, mathematics, geometrics, and fine arts educations.

After defining the classes and the teachers, the next task was to assess the teachers' performance through the TeaM evaluation. Each practice of the TeaM model was presented in the form of a question. For instance, when defining the methodology to be used, the *SP2.3.2.1 Consider Methodologies Effects on Learning Outcomes and Learners' Commitments* was presented in questions: *37.Do you consider the methodologies' effects on learning outcomes* and *38. Do you consider the methodologies' effects on the learner's commitments?*. In total, 90 questions covered the 76 practices of the TeaM model. In contrast to the evaluation at University, where google form was used, this time, school teachers made use of the TeaM website to self-assess their teaching process. The questions are answered in a range of implementation from 0%, 20%, 40%, 60%, 80%, and 100%. The assessment with the TeaM app takes approximately 15 to 20 minutes. Everything is electronically documented. The implementation of 90 questions (corresponding to 76 practices) was calculated to determine if the goals of the model were fulfilled. The calculations followed the CMMI principle of appraisal, meaning that, in our situation, 80% of the practices should have been accomplished. From this derived the determination if and which goals are achieved. The same strategy was applied to goals to see which PAs are satisfied. It means 80% of goals related to a PA should have been achieved. The satisfaction of a group of PAs established the Maturity Level for each teacher.

The next task was to conduct a likert scale questionnaire with the pupils. The questionnaire contained thirteen questions that have the possibility to be answered in a range from "yes/a lot" to "no/nothing". The reason was to have compatibility with the TeaM's scale of assessment. The questions dealt with the extent of the teaching process's efficiency to obtain the knowledge, the effort needed to learn the new content, and the degree of pleasure of the teaching process. Besides, one remaining question was the text field leaving some space for pupils to provide suggestions for further questions they would have liked to address the quality. The questionnaire was provided via google form [Que21]. The same questionnaire was used for all the classes. There were eight informatics classes (in different grades) with 130 pupils.

The last tasks of this third step were to collect and analyze the data from the questionnaires and reflect on the result for improving the TeaM model.

The validity of the questionnaires was considered when analyzing the results. For both teachers' and pupils' questionnaires, the internal consistency of the questions is tested. The detailed description and the results are presented in Section 4.4.2.

As in this research, the sample size was small (n=4), the power analysis test

was observed. The Statistical Power Analysis deals with testing the hypothesis, and during the test, two kinds of errors might be committed - the Type I error and Type II Error [Coh13]. The Type I Error means to reject the Null hypothesis when it is true, and the Type II Error means failing to reject the Null Hypothesis when it is false. Considering the sample size (n=4), then the Type II Error was checked in detail. The desire power level was defined as 0.95, meaning that there is a 95% probability to commit a Type II Error. Based on the results from the Power Correlation Analysis test, it was possible to look for the correlations of the data collected during the interviews. Within the scope of this contribution four additional statistical tests were used to assess the selected data. First, the normal distribution of data was controlled. The Anderson-Darling normality test was used for this purpose [TH08]. Secondly, the Pearson's Correlation Coefficient, the Spearman's Correlation Coefficient and the Kendall's Correlation Coefficient were applied to the data. And finally, a regression analysis (Backward Elimination) was conducted to define which PAs are statistically significant and contribute to the model.

Statistical procedures (as the one we have used) require to assess the assumption of normality. The violation of the normal assumption leads to the invalidity of the interpretation and inferences. In this study the Anderson-Darling normality test [TH08] is used.

The Pearson's correlation coefficient Rho (Rp) looks only on a linear correlation between the variables. It measures the degree of association between them [Ree00]. Pearson's correlation assumes a normal distribution of the values. The test works even when the data are not normally distributed, but it looks only on the linear correlation. The results might indicate no correlation if the data is correlated in a nonlinear manner.

To handle the cases when the data is not normally distributed, the Spearman's rank correlation coefficient Rho (Rs) is used [Ree00]. It is a non-parametric version of Pearson, and uses a monotonic function to describe the correlation between variables. The sample data are ranked separately for each variable and then the correlation is defined.

An alternative of the Spearman's test is the Kendall correlation coefficient Rho (Rk) [NP+97]. It is also a non-parametric test and defines the relation among pairs of data. The data is ranked relatively and partial correlation is possible to be detected.

For this research, the correlation coefficient is explained as follows:

- When Rho is between [0.7, 1.0], the correlation is interpreted as strong relation.
- When Rho is between [0.4, 0.7), the correlation is interpreted as medium relation.
- When Rho is between [0.0, 0.4), the correlation is interpreted as weak relation.

Tab. 4.2: The Cronbach's Alpha test interpretation values

$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

In the interpretation of the results, besides the above values, the significance value (p) of the null hypothesis is considered. The null hypothesis aims at showing that there is no statistical evidence between the variables. The p-value is been defined equal to 0.05 and any probability of the value Rho smaller or equal to p-value indicates stronger evidence against the null hypothesis.

The p-value is used also to interpret the results from the regression analysis in the backward elimination [YL06]. The regression analysis defines which from the independent variables are related to the dependent variable. It explores the best equation that a set of data matches the linear regression line. The backward elimination enters all the independent variable to the equation and eliminates once a time those that have a bigger value than the significant value (p).

4.4.2 Validity of the Questionnaires

It was also of very high relevance to check the validity of the questionnaires before applying the statistical tests. Therefore a reliability test, the Cronbach's Alpha, was used to define the internal consistency of both questionnaires [Cro51]. The Table 4.2 shows the interpretation values of the coefficient. The reliability of a questionnaire is achieved when the coefficient alpha has a value from 0.7 (meaning acceptable) and above.

When talking about the internal consistence, it means testing items that measure the same construct. In this research domain, the construct is the underlying theme of learning quality for the pupils' questionnaire, and the teaching process (with their corresponding phases) for the teachers' questionnaire. The formula 4.4 presents the Cronbach's alpha coefficient, where n is the number of items, V_i is the variance of the total scores and V_t is the variance of the item scores after weighting [Cro51].

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_i V_i}{V_t}\right) \tag{4.4}$$

The pupils' questionnaire was defined through the *Goal Question Metric (GQM)* approach. Two goals objectives were defined: easily acquisition of competencies and learner's satisfaction. For the first goal, two constructs had to be measured: the teaching process's efficiency in obtaining the knowledge and the effort needed to learn the new content. For the teaching process's efficiency the related questions had to be measured:

- How much of the new content was understood?
- How many additional materials were used for learning the new content?
- How was the progress so far?

The effort needed to learn the new content were measured throgh the questions:

- How much time was needed to learn the new content?
- How were the tasks?
- How much hints did the teacher give to solve the tasks?

For the second objective, the related questions, asked how pleasant the teaching process was:

- How much enjoyable was to learn the new content?
- Was the teacher able to explain the new content clearly?
- Was the teacher able to answer the questions?
- Was the teacher predisposing to help you?
- Was the teacher friendly?
- Was the teacher patient?
- How would you evaluate this course overall?

By applying the five point likert scale questionnaire with the pupils, we had a record of 130 respondents for the 13 items. Those data were tested via Cronbach's alpha coefficient, and the result was 0.889 (see Figure 4.10). Looking at the interpretation Table 4.2 of Cronbach's alpha coefficient, 0.889 means that the pupils questionnaire is reliable, as it has a "good" internal consistency.

On the other side, the Cronbach's alpha test for the six point likert scale teachers' questionnaire was applied into four constructs. Firstly, the teaching process includes four phases representing four different constructs. Secondly, we considered that the

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.889	.890	13

Fig. 4.10: The results from the Chronbach's Alpha test for the questionnaire filled by learners. (n=13)

alpha test is sensitive, meaning that a larger number of items tested can result in a larger alpha coefficient. We didn't want to influence the alpha coefficient, as the teachers' questionnaire contains 90 questions.

Therefore, the questions were split based on their PAs, corresponding to a specific teaching phase. This means that the first group of questions included those questions related to PAs of the Initialization phase (Figure 2.1). In other words, were tested the group of questions related to P1.1 (Determining Commitment), P1.2(Availability of Resources), and P1.3 (Discovering Needs). The number of items was 14 with an alpha coefficient of 0.853 (see Figure 4.11), meaning that, this group of questions, has a "good" internal consistency.

Reliability Statistics

Cronbach's Alpha	N of Items
.853	14

Fig. 4.11: The results from the Chronbach's Alpha test for the questions related to the Initialization phase of the teaching process . (n=14)

The next alpha test was applied to the group of questions related to P2.1, P2.2, P2.3, and P2.4 (Preparation Phase). The construct was the underlying theme of teachers' preparation. The number of items was 33, and the alpha coefficient was 0.969. It is interpreted as excellent internal consistency of these group of questions (see Figure 4.12).

Furthermore, satisfying results came out from the third test covering the questions related to P3.1 and P3.2. The 16 items (questions) of the Enactment phase yield to a 0.893 alpha coefficient, defining the questions' reliability as "good" (see Figure 4.13).

Last but not least, 27 items were tested within the construct of the Quality and

Reliability Statistics

Cronbach's Alpha	N of Items
.969	33

Fig. 4.12: The results from the Chronbach's Alpha test for the questions related to the Preparation phase of the teaching process . (n=33)

Incident Control. As it is seen in Figure 4.14, the alpha coefficient is 0.981 signifying an excellent internal consistency of the questionnaire.

Reliability Statistics

Cronbach's Alpha	N of Items
.893	16

Fig. 4.13: The results from the Chronbach's Alpha test for the questions related to the Enactment phase of the teaching process . (n=16)

Reliability Statistics

Cronbach's Alpha	N of Items
.981	27

Fig. 4.14: The results from the Chronbach's Alpha test for the questions related to the Quality and Incident Control phase of the teaching process . (n=27)

All in all, the Cronbach's alpha test demonstrated the internal consistency of both the questionnaires used in this research.

4.4.3 Results

The data collected through the validated questionnaires were used later on for the statistical tests. The first statistical test considered was the Power Correlation Test. On the one hand, the Power test helps determine the sample size before starting the study - meaning how many participants are needed to yield satisfying statistical/predictive power. On the other hand, with the Power test, it is possible to define how strong is the statistical power of calculations with the current sample size.

The Power Analysis test has four tightly related quantities: the sample size (n), the effect size (r), the significance level (Type I Error), and the power (Type II Error). In our setting, the Power Correlation test was performed twice. Firstly, it was checked for the perfect sample size when the effect size was defined as 0.8, the significance level as 0.05, and the power as 0.95. The results demonstrated that about 13 participants are needed, so that correlation analysis has enough statistical power to detect correlations of +/- 0.8 as significant. Unfortunately, due to the COVID-19 restrictions, it was impossible to have a larger sample size in this step of the study, yielding to the participation of four teachers only.

Considering such a situation, then a second Power Correlation test was performed, where the sample size was established as 4, the significance level as 0.05, and the power as 0.95. The results showed that the correlation analysis with 4 participants only has enough statistical power to detect correlations of +/- 0.99. In other words, the more participants, the smaller the detectable effect sizes can be. With 4 participants, it was enough statistical power to detect only very strong effect sizes. This allowed us to apply the correlations test and look at any strong correlations between MLs, pupils' feedback, and the PAs.

For presenting the relation between Maturity Levels and the pupils' feedback, a scatter plot (see Figure 4.15) was produced. This helped to get the first feeling about possible relations and differences between them. On the x-axis are the Maturity Levels on a scale from 1 to 5, where 5 means the highest Maturity Level. On the y-axis is the pupils' feedback on a scale from 1 to 5, where 5 represents the course's satisfaction. The linear trend-line in Figure 4.15 indicates a slightly increasing linear line between the pupils' feedback and the Maturity Level. In other words, the higher the Maturity Level is, the higher is the pupils' feedback. The scatter plot also generated the R correlation value ($R^2 = 0.040$), meaning that approximately 4% of the variation of pupils' feedback can be explained by the Maturity level. Actually not pretty much, as this implies that 96% of the pupils' feedback can not be describe through the Maturity Level.

The Scatter plot gave a first impression of how data are distributed. It also shows that few data points are spread away from the trend-line. For this reason, a statistical test is required to interpret them. By keeping in mind that the ML is related to the PAs, then the 12 PAs of the TeaM model have always been considered variables during the statistical tests. Due to the relatively small sample data, the Shapiro-Wilk test of a normal distribution is used [SW65]. The null hypothesis in the Shapiro-Wilk test assumes that the variable from which the sample was extracted follows a normal distribution. For every computed p-value lower than the significance level alpha = 0.05, the null hypothesis is rejected. Considering the results from Shapiro-Wilk's test (see Figure 4.16), all the PAs have their p-value greater than 0.05, meaning that they are normally distributed.

"Sig" or p-value is the probability of the sample's deviation if the population

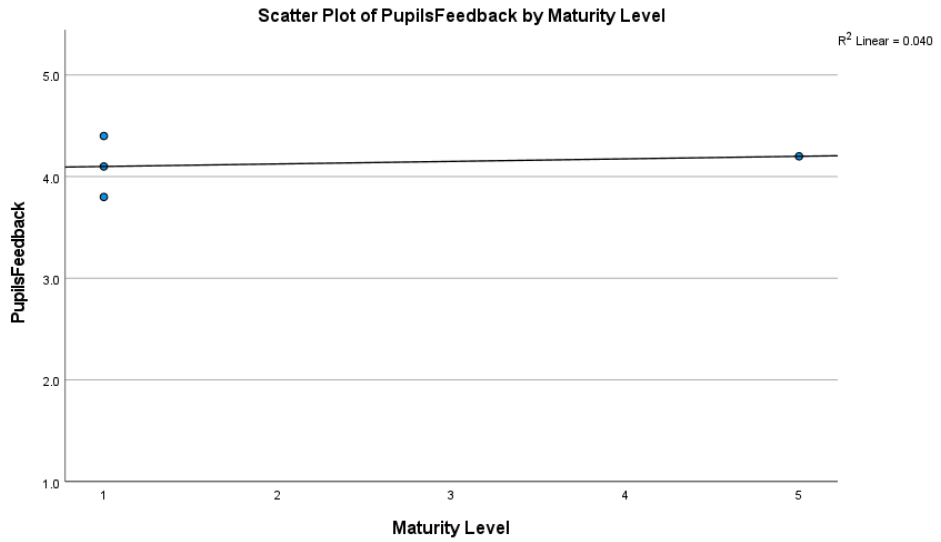

Fig. 4.15: Scatter-plot for visualizing the relation between the Maturity Levels and the pupils' feedback.

is normally distributed. For instance, P1.2 Availability of Resources has a p-value = 0.086. If this variable is normally distributed in the data set, there is an 8.6% chance to find a non-normality observed in our sample.

For finding a correlation between the set of variables (PAs, ML and Pupils' feedback), statistical tests (Pearson, Spearman and Kendall) where applied (see Figures 4.17, 4.18, 4.19). The Rho-values marked bold have a p-value smaller than 0.05. It means that the null hypothesis is rejected and that the Rho-values show some statistical evidence between the variables. The other Rho-values (not marked) have a p-value bigger than 0.05 and must be interpreted with care. This research focused and considered only those Rho-values that have statistical evidence.

As the variables are normally distributed, the Pearson correlation test was used first. One of the objectives of this research was the relationship between pupils' feedback and the ML generated for the school teachers. When looking at Pearson's results, such relation is not of existence. But there is statistical evidence of ML's strong positive relationship with P4.1 Observing the Teaching Process (0.968)and P4.3 Improve Teaching (0.980). Furthermore, the P4.3 Improve Teaching has a strong positive relationship with P2.4 Incident Management and P4.1 Observing the Teaching Process. P4.2 Reflecting on the Teaching Process also has a strong positive relationship with P3.1 Delivery and Consolidation, P3.2 Assessment Management, and P4.1 Observing the Teaching Process. Another strong positive correlation is between P2.4 Incident Management and P1.3 Discovering Needs. Last but not least, strong positive relationships is also shown between the P3.2 Assessment Manage-

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
P1.1 Determining Commitment	0.996	4	**0.985**
P1.2 Availability of Resources	0.791	4	**0.086**
P2.1 Design Objectives	0.842	4	**0.202**
P2.2 Content Planning	0.982	4	**0.916**
P3.1 Delivery and Consolidation	0.934	4	**0.618**
P3.2 Assessment Management	0.991	4	**0.963**
P1.3 Discovering Needs	0.919	4	**0.530**
P2.4 Incident Management	0.892	4	**0.392**
P2.3 Methodology Selection	0.932	4	**0.607**
P4.1 Observing the Teaching Process	0.841	4	**0.197**
P4.2 Reflecting on TP	0.983	4	**0.921**
P4.3 Improve Teaching	0.779	4	**0.070**
ML	0.630	4	0.001
Pupils'Feedback	0.982	4	**0.911**

Fig. 4.16: The Shapiro-Wilk normality test for the 12 PAs.

ment and the P2.2 Content Planning.

Based on the Pearson statistical results, the P4.1 Observing the Teaching Process, P4.2 Reflecting on the Teaching Process, and P4.3 Improve Teaching are more frequently associated in relations. This emphasize the importance of the fourth phase of the teaching process (Quality and Incident Control) in the TeaM model.

Spearman's correlation coefficient test is recommended when the variables are not normally distributed and there is a nonlinear relation. The results are shown in Figure 4.18. Similarly, with the other statistical tests, the P-value indicates whether the results happened by chance in the sample or that a real relationship exists in the population. When the P-values are lower than alpha= 0.05, there is evidence of a relationship in the population.

Alike the aforementioned test, the Spearman test shows that there is no correlation between ML and the pupils' feedback. Unlike Pearson, Spearman computes that there is also no correlation between the MLs and the PAs.

From the first impact of the results, it is noticeable that the test has generated only strong relationships between the variables. When looking at the correlation between all the PAs, the Spearman test emphasizes the importance of the quality and incident control phase of the teaching process due to considerable strong correlations of the related PAs of this phase with other PAs. For instance, P4.3 Improve Teaching has a strong relationship with P2.2 Content Planning, P3.1 Delivery and Consolida-

Pearson Correlations

		P1.1 Determining Commitment	P1.2 Availability of Resources	P2.1 Design Objectives	P2.2 Content Planning	P3.1 Delivery and Consolidation	P3.2 Assessment Management	P1.3 Discovering Needs	P2.4 Incident Management	P2.3 Methodology Selection	P4.1 Observing the Teaching Process	P4.2 Reflecting on TP	P4.3 Improve Teaching	ML
P1.2 Availability of Resources	Pearson Correlation	.465												
	Sig. (2-tailed)	.535												
	N	4												
P2.1 Design Objectives	Pearson Correlation	.894	.185											
	Sig. (2-tailed)	.106	.815											
	N	4	4											
P2.2 Content Planning	Pearson Correlation	.803	-.092	.751										
	Sig. (2-tailed)	.197	.908	.249										
	N	4	4	4										
P3.1 Delivery and Consolidation	Pearson Correlation	.947	.257	.810	.938									
	Sig. (2-tailed)	.053	.743	.190	.062									
	N	4	4	4	4									
P3.2 Assessment Management	Pearson Correlation	.865	-.031	.860	**.983***	.948								
	Sig. (2-tailed)	.135	.969	.140	.017	.052								
	N	4	4	4	4	4								
P1.3 Discovering Needs	Pearson Correlation	.665	-.070	.482	.931	.869	.853							
	Sig. (2-tailed)	.335	.930	.518	.069	.131	.147							
	N	4	4	4	4	4	4							
P2.4 Incident Management	Pearson Correlation	.715	.065	.487	.911	.895	.837	**.991****						
	Sig. (2-tailed)	.285	.935	.513	.089	.105	.163	.009						
	N	4	4	4	4	4	4	4						
P2.3 Methodology Selection	Pearson Correlation	.706	.804	.322	.414	.671	.399	.521	.633					
	Sig. (2-tailed)	.294	.196	.678	.586	.329	.601	.479	.367					
	N	4	4	4	4	4	4	4	4					
P4.1 Observing the Teaching Process	Pearson Correlation	.854	.248	.627	.913	.965*	.876	.941	.972*	.739				
	Sig. (2-tailed)	.146	.752	.373	.087	.035	.124	.059	.028	.261				
	N	4	4	4	4	4	4	4	4	4				
P4.2 Reflecting on TP	Pearson Correlation	.852	.029	.752	.992**	**.971***	**.975***	.940	.936	.526	**.955***			
	Sig. (2-tailed)	.148	.971	.248	.008	.029	.025	.060	.064	.474	.045			
	N	4	4	4	4	4	4	4	4	4	4	4		
P4.3 Improve Teaching	Pearson Correlation	.821	.268	.564	.883	.941	.835	.941	**.977***	.767	**.997****	.931		
	Sig. (2-tailed)	.179	.732	.436	.117	.059	.165	.059	.023	.233	.003	.069		
	N	4	4	4	4	4	4	4	4	4	4	4		
ML	Pearson Correlation	.816	.440	.502	.781	.900	.737	.864	.925	.877	**.968***	.851	**.980***	
	Sig. (2-tailed)	.184	.560	.498	.219	.100	.263	.136	.075	.123	.032	.149	.020	
	N	4	4	4	4	4	4	4	4	4	4	4	4	
Pupils'Feedback	Pearson Correlation	-.402	-.123	-.712	-.103	-.171	-.281	.260	.266	.175	.094	-.079	.169	.200
	Sig. (2-tailed)	.598	.877	.288	.897	.829	.719	.740	.734	.825	.906	.921	.831	.800
	N	4	4	4	4	4	4	4	4	4	4	4	4	4

Fig. 4.17: Pearson Rho for the 12 PAs, ML and Pupils' Feedback. The results marked bold have a p-value smaller then 0.05 and indicate a correlation between variables. (N=4)

tion, P3.2 Assessment Management, P4.1 Observing the Teaching Process, and P4.2 Reflecting on the Teaching Process. Analogous relationships are also to be found for P4.2 Reflecting on the Teaching Process. Furthermore, P4.1 is strongly related to P2.2 Content Planning, P3.1 Delivery and Consolidation, and P3.2 Assessment Management.

Similar to Pearson, P2.4 Incident Management has a strong relationship with P1.3 Discovering Needs. Strong positive relationships are also shown for the P3.2 Assessment Management with the P2.2 Content Planning and P3.1 Delivery and Consolidation.

Differing from Pearson, the Spearman tests generated two additional strong correlations, those of P3.1 Delivery and Consolidation with P2.2 Content Planning and P2.1 Design Objectives with P1.1 Determining Commitment.

Spearman Correlations

		P1.1 Determining Commitment	P1.2 Availability of Resources	P2.1 Design Objectives	P2.2 Content Planning	P3.1 Delivery and Consolidation	P3.2 Assessment Management	P1.3 Discovering Needs	P2.4 Incident Management	P2.3 Methodology Selection	P4.1 Observing the Teaching Process	P4.2 Reflecting on TP	P4.3 Improve Teaching	ML
P1.2 Availability of Resources	Correlation Coefficient	.738												
	Sig. (2-tailed)	.262												
	N	4												
P2.1 Design Objectives	Correlation Coefficient	**1.000****	.738											
	Sig. (2-tailed)	.000	.262											
	N	4	4											
P2.2 Content Planning	Correlation Coefficient	.800	.211	.800										
	Sig. (2-tailed)	.200	.789	.200										
	N	4	4	4										
P3.1 Delivery and Consolidation	Correlation Coefficient	.800	.211	.800	**1.000****									
	Sig. (2-tailed)	.200	.789	.200	.000									
	N	4	4	4	4									
P3.2 Assessment Management	Correlation Coefficient	.800	.211	.800	**1.000****	**1.000****								
	Sig. (2-tailed)	.200	.789	.200	.000	.000								
	N	4	4	4	4	4								
P1.3 Discovering Needs	Correlation Coefficient	.400	-.105	.400	.800	.800	.800							
	Sig. (2-tailed)	.600	.895	.600	.200	.200	.200							
	N	4	4	4	4	4	4							
P2.4 Incident Management	Correlation Coefficient	.400	-.105	.400	.800	.800	.800	**1.000****						
	Sig. (2-tailed)	.600	.895	.600	.200	.200	.200	.000						
	N	4	4	4	4	4	4	4						
P2.3 Methodology Selection	Correlation Coefficient	.632	.833	.632	.316	.316	.316	.316	.316					
	Sig. (2-tailed)	.368	.167	.368	.684	.684	.684	.684	.684					
	N	4	4	4	4	4	4	4	4					
P4.1 Observing the Teaching Process	Correlation Coefficient	.800	.211	.800	**1.000****	**1.000****	**1.000****	.800	.800	.316				
	Sig. (2-tailed)	.200	.789	.200	.000	.000	.000	.200	.200	.684				
	N	4	4	4	4	4	4	4	4	4				
P4.2 Reflecting on TP	Correlation Coefficient	.800	.211	.800	**1.000****	**1.000****	**1.000****	.800	.800	.316	**1.000****			
	Sig. (2-tailed)	.200	.789	.200	.000	.000	.000	.200	.200	.684	.000			
	N	4	4	4	4	4	4	4	4	4	4			
P4.3 Improve Teaching	Correlation Coefficient	.800	.211	.800	**1.000****	**1.000****	**1.000****	.800	.800	.316	**1.000****	**1.000****		
	Sig. (2-tailed)	.200	.789	.200	.000	.000	.000	.200	.200	.684	.000	.000		
	N	4	4	4	4	4	4	4	4	4	4	4		
ML	Correlation Coefficient	.775	.544	.775	.775	.775	.775	.775	.775	.816	.775	.775	.775	
	Sig. (2-tailed)	.225	.456	.225	.225	.225	.225	.225	.225	.184	.225	.225	.225	
	N	4	4	4	4	4	4	4	4	4	4	4	4	
PupilsFeedback	Correlation Coefficient	-.400	-.211	-.400	-.200	-.200	-.200	.400	.400	.316	-.200	-.200	-.200	.258
	Sig. (2-tailed)	.600	.789	.600	.800	.800	.800	.600	.600	.684	.800	.800	.800	.742
	N	4	4	4	4	4	4	4	4	4	4	4	4	4

Fig. 4.18: Spearman Rho for the 12 PAs, ML and Pupils' Feedback. The results marked bold have a p-value smaller then 0.05 and indicate a correlation between variables. (N=4)

The last correlation test used was the Kendall test. Kendall test checks for nonlinear partial relations. One particular feature of this test is that it works fine on small sample size. So it is appropriate for our sample. The most interesting result concern those relationships considered as statistically significant. Figure 4.19 shows that Kendall has generated exactly the same significant correlations as the Spearman test. The values of the other correlation results, considered as not statistically significant, differ slightly from those of the Spearman test. But analyzing them is not the scope of this research.

Through the research was of interest to check which PAs contribute to the model. For this reason, a regression analysis using a backward elimination algorithm was performed (see Figure 4.20). The 12 PAs formed the independent variables, and those with the highest p-value (always considered those with a p-value bigger than 0.05) were eliminated. The dependent variable was the pupils' feedback.

In the equation 4.1, b is the slope of the line (equation 4.3) and a is the y-intercept (equation 4.2). The test results demonstrated that none of the 12 independent variables (PAs) is of statistical significance in relation to the dependent variable pupils'

Kendall Correlations

		P1.1 Determining Commitment	P1.2 Availability of Resources	P2.1 Design Objectives	P2.2 Content Planning	P3.1 Delivery and Consolidation	P3.2 Assessment Management	P1.3 Discovering Needs	P2.4 Incident Management	P2.3 Methodology Selection	P4.1 Observing the Teaching Process	P4.2 Reflecting on TP	P4.3 Improve Teaching	ML
P1.2 Availability of Resources	Correlation Coefficient	.548												
	Sig. (2-tailed)	.279												
	N	4												
P2.1 Design Objectives	Correlation Coefficient	**1.000***	.548											
	Sig. (2-tailed)	.042	.279											
	N	4	4											
P2.2 Content Planning	Correlation Coefficient	.667	.183	.667										
	Sig. (2-tailed)	.174	.718	.174										
	N	4	4	4										
P3.1 Delivery and Consolidation	Correlation Coefficient	.667	.183	.667	**1.000***									
	Sig. (2-tailed)	.174	.718	.174	.042									
	N	4	4	4	4									
P3.2 Assessment Management	Correlation Coefficient	.667	.183	.667	**1.000***	**1.000***								
	Sig. (2-tailed)	.174	.718	.174	.042	.042								
	N	4	4	4	4	4								
P1.3 Discovering Needs	Correlation Coefficient	.333	-.183	.333	.667	.667	.667							
	Sig. (2-tailed)	.497	.718	.497	.174	.174	.174							
	N	4	4	4	4	4	4							
P2.4 Incident Management	Correlation Coefficient	.333	-.183	.333	.667	.667	.667	**1.000***						
	Sig. (2-tailed)	.497	.718	.497	.174	.174	.174	.042						
	N	4	4	4	4	4	4	4						
P2.3 Methodology Selection	Correlation Coefficient	.548	.800	.548	.183	.183	.183	.183	.183					
	Sig. (2-tailed)	.279	.126	.279	.718	.718	.718	.718	.718					
	N	4	4	4	4	4	4	4	4					
P4.1 Observing the Teaching Process	Correlation Coefficient	.667	.183	.667	**1.000***	**1.000***	**1.000***	.667	.667	.183				
	Sig. (2-tailed)	.174	.718	.174	.042	.042	.042	.174	.174	.718				
	N	4	4	4	4	4	4	4	4	4				
P4.2 Reflecting on TP	Correlation Coefficient	.667	.183	.667	**1.000***	**1.000***	**1.000***	.667	.667	.183	**1.000***			
	Sig. (2-tailed)	.174	.718	.174	.042	.042	.042	.174	.174	.718	.042			
	N	4	4	4	4	4	4	4	4	4	4			
P4.3 Improve Teaching	Correlation Coefficient	.667	.183	.667	**1.000***	**1.000***	**1.000***	.667	.667	.183	**1.000***	**1.000***		
	Sig. (2-tailed)	.174	.718	.174	.042	.042	.042	.174	.174	.718	.042	.042		
	N	4	4	4	4	4	4	4	4	4	4	4		
ML	Correlation Coefficient	.707	.516	.707	.707	.707	.707	.707	.707	.775	.707	.707	.707	
	Sig. (2-tailed)	.180	.346	.180	.180	.180	.180	.180	.180	.157	.180	.180	.180	
	N	4	4	4	4	4	4	4	4	4	4	4	4	
Pupils'Feedback	Correlation Coefficient	-.333	-.183	-.333	.000	.000	.000	.333	.333	.183	.000	.000	.000	.236
	Sig. (2-tailed)	.497	.718	.497	1.000	1.000	1.000	.497	.497	.718	1.000	1.000	1.000	.655
	N	4	4	4	4	4	4	4	4	4	4	4	4	4

Fig. 4.19: Kendall Rho for the 12 PAs, ML and Pupils' Feedback. The results marked bold have a p-value smaller then 0.05 and indicate a correlation between variables. (N=4)

feedback. This is something expected, seeing the outcomes from the correlations tests performed above. It is worth mention that such results from the backward elimination might have been influenced by the low number of the observed data.

Finding the correlation of PAs with the ML-s and how they can be rearranged in ML was also of importance . The study results suggested that the split of PAs into Maturity Level should remain the same, at least until larger sample size is tested and analyzed.

4.4.4 Discussions

All the possible variables were considered for answering the two questions of this third step of the research. It was checked in detail how these variables contribute to the TeaM model. The results are surprising, but they underlay the importance of the teaching process phases and their related PAs. It can be said that they are somehow expected when comparing the TeaM evaluation results in the schools' domain with those of pupils' feedback. In contrast to the TeaM model, the pupils' feedback

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	1.000[a]	1.000	.	.	1.000	.	3	0	.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.188	3	.063	.	.[b]
	Residual	.000	0	.		
	Total	.188	3			

Fig. 4.20: Results of the Backward Elimination where Pupils's Feedback was the dependent variable (N=13)

estimates only two aspects of the quality of teaching, pupils' satisfaction, and easy competence acquisition. The result from the assessment are based on the pupils' perception. On the other hand, the TeaM model considered all the processes that influence teaching quality, and the evaluation relies on standards, avoiding personal feedback.

Although three correlation tests were applied (Pearson, Spearman, Kendall), the results slightly differ from each other. Better saying the Spearman and Kendall have computed the same outcomes. So, the main differences are between these two with the Pearson test. The three tests corroborate no relation when examining the ML and pupils' feedback correlation.

A difference is seen in the relation MLs with PAs. Unlike Spearman and Kendall, Pearson defines that the TeaM model is appropriate in school teaching when at least two Process Areas are considered. It means that the school teachers in Carinthia pay attention only to observing the teaching process and its improvement. The interviewed teachers have considerable teaching experience, and as a consequence, some practices such as content planning, methodology selection, determining commitment, etc., are not paid the required attention. It is assumed that in such settings, they put more effort into improving the teaching process by also observing it.

Differences are also to be found in the relations of PAs between them. The Pearson test computed a strong correlation between P4.3 Improve Teaching and P2.4 Incident Management. Such a relation is presented neither in the Spearman test nor in the Kendall test. Logically, this relation should make sense as incidents are considered while aiming to improve the course quality.

Inter alias, there are numerous correlations computed by Spearman and Kendall tests, which are not considered by the Pearson teat. The strong correlation P2.1 Design Objectives and P1.1 Determining Commitment is relevant as one goal of P1.1 is to agree upon curricula. For designing the objectives of a course, the teachers

should refer to the curricula. Vice versa also has meaning as one of a teacher's duties is to define the course's objectives.

The strong correlation between P2.2 Content Planning and P3.1 Delivery and Consolidation is a relation determined by both Kendall and Spearman. This is a significant relation, as the lessons(courses) should be conducted according to the course plan already defined by the teacher. The preparation of the materials, learning content, and the unit schedule are planned to be conducted in practice.

Interesting is also the relationship of P4.1 Observing the Teaching Process with P2.2 Content Planning, P3.1 Delivery and Consolidation, and P3.2 Assessment Management. This relation is reasonable for a teacher. It is essential to monitor the course's planning, the conduction of the lessons according to the plan, and the assessment results for enhancing the quality of teaching.

Spearman and Kendall computed another correlation, that of P4.2 Reflecting on the Teaching Process with P2.2 Content Planning. This is a significant relation (although Pearson ignores it) because reflecting on the analyzed results about how teaching content was planned is of higher relevance for improving the course's quality.

Moreover, P3.2 Assessment Management and P3.1 Delivery and Consolidation is another relation presented only by Kendall and Spearman. This is quite a normal relationship as for collecting the learning outcomes, an assessment of the delivered units needs to be conducted.

Finally, only Kendall and Spearman computed the additional correlations between P4.3 Improve Teaching with P2.2 Content Planning, P3.1 Delivery and Consolidation, P3.2 Assessment Management, and P4.2 Reflecting on Teaching Process. Straight thinking, by reflecting on how the course is planned, how it is conducted, and on the learning outcomes, is explicitly derived what and how to improve it.

The results from the three tests approve once again the grouping of PAs into their corresponding Maturity Level. An example is the strong correlation of P1.3 Discovering Need and P2.4 Incident Management computed by the three tests. These PAs are the only component of the Maturity Level 3 (Repeatable). Furthermore, such grouping into MLs is ratified by Kendall and Spearman in the correlation P4.2 Reflecting on the Teaching Process with P4.3 Improve Teaching. The two PAs are the only PAs of the ML 5 (Optimizing).

The only correlation not found is that of PAs corresponding the ML 4 (Stable). None of the three tests computed a relationship between P2.3 Methodology Selection and P4.1 Observing the Teaching Process.

Analyzing the Pearson, Spearman, and Kendall tests' computed values, three PAs are not included in any relationship. These are P1.2 Availability of Rescues, P2.1 Design Objective, and P2.3 Methodology Selection. The first instinct makes us think that maybe these variables are redundant, but when looking at the statistical test results from university teachers, these PAs are considered correlated. Perhaps a

second test of the TeaM model in the school context with more extensive teachers' participation might overturn the result generated in this third step of the search. But this is addressed as future work.

4.4.5 Threads of Validity

Many factors contributed to the results. Defining the correlation of pupils' feedback with ML was at a certain level difficult. First, the number of questions in TeaM (90) was considerable higher compared to the pupils' questions (13). Secondly, the results come from two different domains. Pupils' feedback results are generated by pupils, and the answers might not have been given objectively. Teachers answered the TeaM questionnaire, and we assume them being honest, as no ranking was produced. Finally, the pupils' questionnaire includes only some of the teaching process practices to address the quality.

Another factor that might have influenced the results was the number of participants. Four teachers with a total of 130 pupils were not the optimal sample size to test the model.

Apart from that, for the study's implementation, it was tried to avoid any bias by selecting different teachers in diverse schools in Carinthia, choosing teachers from different fields of study, and different class grades. However, it cannot be guaranteed that some of the teachers and pupils could speak to each other, influencing the results. The same questionnaires were used throughout the study. The study duration was no more than two weeks, and the participant could not evolve their ways of teaching in-between. Participation in the questionnaire was voluntary.

Finally, the results are restricted to some schools in Carinthia and might not be generalized to other schools in Austria or broader.

The third step of the research in this thesis demonstrated the TeaM model's applicability at some schools in Carinthia and provided a stable version of the TeaM model.

5. SUMMARY AND CONCLUSION

5.1 Conclusion

This research started as a desire to contribute in the field of teaching quality. More specifically, finding out ways to assess and improve the quality of teaching. Therefore, the main research question was:

- How to assess and improve the quality of teaching in informatics at the university and schools in Carinthia?

Through a literature survey, discovering gaps in this research domain, turned out the idea that teaching quality might be related to the teaching process. For this reason, the first research question was

RQ1 *How are the teaching process and the quality of teaching defined?*

By a detailed literature investigation, followed by some experts' review and evaluation, the teaching process was defined as a collection of best practices grouped into sub-phases . Hence, by this definition, the teaching process consists of four sub-phases, dealing respectively with initialization, preparation, enactment, and quality and incident control (Figure 2.1). These phases are then split into sub-processes representing each group of best practices (PAs).

Similarly, a literate survey was conducted to come up with an explicit definition of the teaching quality. As a results it is defined as a term that has three functionalities:

(a) adhere to the state of the art of teaching

(b) enable learners to acquire competences easily

(c) ensure that learners are satisfied with the courses

The first functionality represents the activities (practices) that teachers apply during their teaching process. The second functionality addresses the efficiency if the teaching process enable learners to obtain the knowledge. Finally, the satisfaction of the learners is considered as well.

Going further with the objectives of this thesis, the second research question was:

RQ2 *What possibilities are there to assess the teaching process and the quality of teaching?*

The literature survey gave a broad overview of the possible ways to assess the quality of teaching. On the one hand, these "traditional" assessment methods like students' feedback, inspectors, self-assessment, etc., are seen as objective/subjective. On the other hand, the assessment models like AQRT, TEQAS, CEM, TALIS, etc., consider one or two teaching quality factors, and only some of these models are applicable. In addition to these categories is the category of the maturity models. These models focused either on curricula, or on course design, or institutions. Only some of them have demonstrated the applicability. Just one approach addresses the teaching process as a way to assess the quality of teaching. But this model is applicable for the university level, and further, it has a limitation of PAs [CCC14]. Therefore, this thesis provides the Teaching Maturity (TeaM) model. TeaM is the model that considers the teaching process to assess the teaching quality for the university and the school level. In addition to this, it tries to cover all the possible PAs.

Given the above state, the research questions three and four were:

RQ3 *To what extent is the quality of teaching influenced by the teaching process in informatics in schools and at the university in Carinthia?*

RQ4 *To what extent can a maturity model be used to improve the quality of teaching informatics at schools and university in Carinthia?*

The TeaM model was an essential component to define the extent to which a maturity model (teaching process) can influence teaching quality. Therefore, the teaching process was decomposed into sub-processes. For each sub-process, the best practices (PAs) with their related goals were established. This allowed the implementation of the TeaM Model with university and school teachers.

When applying the TeaM model in these domains, are noticeable some differences between university and school teachers. The results showed that there are in total four main differences: Documentation, methodology, teaching process observation, and reflection are not considered by university teachers [RB18b]. On the model level, we can say that university and school teachers differ in 9 out of 12 PAs in our TeaM model. Apart from differences, we also have additional practices suggested by the university teachers that might be relevant and considered by the school's teachers[RB18b]. Two practices are suggested: the repetitive and standardized evaluation of the course and various (and anonymous) ways to communicate with the pupils [RB18b]. The teachers' comments showed that they like the idea behind the TeaM model and looking at the teaching process as a whole. They were somehow surprised about the compact representation of the practices in our framework. The

TeaM model made them think about some practices they ignored before. Looking at the feedback results, we can also state that, eventually, with some minor extensions, the TeaM model is appropriate for university and school teachers [RB18b].

When going into more details in the university context, the statistical results show that the TeaM model is applicable in universities but limited to some Process Areas. University teachers are concentrated on one Process Area, planning the content of their course [RB19b]. Only some of them looked tangentially on the other Process Areas. The results show that the extent of correlation between the Maturity Level and the students' perception of the course is weak. But, on the other hand, they show that the extent of correlation between the students' perception and PAs (P2.2 Content Planning) is strong based on Spearman test [RB19b].

Meanwhile, the statistical results in the school context emphasize the importance of the teaching process phases and their related PAs. The TeaM model is applicable in schools, and the teachers pay attention to the PAs, but mostly the observation and improvement of the teaching process. The extent of correlation between pupils' feedback and Maturity Level is inferior, but we argue that this may have been affected by the low number of participants in the study. Nevertheless, we believe that teaching is a process that comprises many process areas. Those areas contribute as well to the quality of teaching. Thus, teachers are encouraged to think and use the proposed areas to improve their teaching quality of the courses [RB19b].

To conclude, the teaching process has an implicit influence on teaching quality because the teachers implement most of the sub-process (PAs). Still, they never considered the teaching process as a whole. By making use of the TeaM model, they became aware and agreed on these sub-processes and seeing teaching as a process. Therefore, at an acceptable level, the maturity model can be used to improve the quality of teaching in informatics at schools and university in Carinthia. However, these results are restricted to and relay only for some teachers at Klagenfurt Universität, and few schools in Carinthia.

5.2 Summary

The question of how to assess and improve teaching quality was a boost to start this research. Chen et al. evidenced that a better quality of teaching is achieved when the teaching process is considered [CCC14]. Their model was the only which address the teaching process but yet not applied, and it has some limitations on practices [CCC14]. Therefore, a study was conducted to overcome the gaps from the model of Chen et al. In this circumstance, a Teaching Maturity (TeaM) model was created, focusing on the teaching process and teachers at all levels, primary, secondary, and university education. The applicability of the model can help the educational institution evaluate and improve its teaching quality (by, when required

producing a ranking) or allowing the teachers to assess and improve their teaching process.

By means of this research so far, we were able to define the teaching process, to define the quality of teaching, and create the TeaM model. We also approved that the TeaM model is understandable and acceptable by (a selected set of) informatics teachers. The TeaM's Process Areas, Specific Goals and Practices were assessed and confirmed by the study results. The TeaM model was evaluated in practice with some university teachers at Universität Klagenfurt and a limited number of school teachers in Carinthia. It generated each teacher how mature their teaching course was, and these results were compared with the learners' feedback for these courses. The evaluation's results demonstrated that the model raised teachers' awareness to consider the teaching process as an influence on teaching quality.

So far, there is a stable version of the model and a web application of it, where teachers can do a self-assessment for defining their teaching quality.

5.3 Further Work

Beyond a self-assessment framework, TeaM Model might be used as a comparison tool to generate a ranking of the educational institutions based on best performance and/or to generate a ranking of best-performing teachers. Further evaluation of the model is meant with larger sample size. Due to COVID 19 restrictions, it was impossible to test TeaM model, even with other universities and schools in Austria and broader, in different schools forms and subjects. This is addressed as future work.

Moreover, the latest version of CMMI 2.0 does not make use of Generics Goals anymore. Hence a reformation structure backbone of the TeaM model can be considered in the future.

Furthermore, providing additional practices that might include relevant information to enhance learning, for instance: existing types of methodologies, multimedia for teaching, etc. Such an extension of the model could add to it even more functionality.

Finally, thinking about the possibility of enlarging the TeaM as a maturity model that would address the quality by also focusing on the learning process is another issue left for future work.

APPENDIX

A. PRE - STUDY QUESTIONNAIRE

For defining the best practices of the TeaM model, these questions where provided to informatics teachers. Their experience and activities were transform in Specific Practices. The questionnaire was split in four phases, corresponding to the four phases of the teaching process.

Initialization Phase

1. Are you aware that there might be a formal written form of duties as a teacher? Do you have to sign it?
2. Do you try to embed your lectures into the existing curricula (by also coordinating with your colleagues)? If yes, which are the steps that you follow?
3. Do you think the environment (classroom settings, tables, etc.) is an important element that might influence teaching? Do you try to manage it? How?
4. Do you think the technical infrastructure is an important element that might influence teaching? Do you utilize it? How do you manage it?
5. Do you take in consideration different requirements that might come from others (students/pupils, colleagues, directors, etc.)? If yes, how to do specify them?

Preparation Phase

6. During your preparation, do you define the course aims and plan? How do you do that?
7. Do you define how to nearly measure the objectives of your course? Do you define some qualitative and quantitative measurement? If yes, how you do so?
8. During you preparation for teaching do you develop the learning content (topics/ sub-topics)? If yes, which steps do you follow? Do you also include external content? How you do that?
9. Do you define the teaching materials? Is there a specific strategy you follow for preparing them?

10. Do you integrate external teaching materials in your course? If yes, how do you do that?

11. Do you schedule your teaching units? Which steps do you follow?

12. Are you aware of different teaching methodologies? Which are?

13. If you analyze the methodologies, how do you do that?

14. in your course you might use one or more methodologies, how do you define which methodologies to use?

15. Do you take in consideration possible problems that might occur during the teaching? If yes, how?

16. How do you analyze the possible problems?

17. Do you define a corrective plan for the problems? Which steps do you follow for defining it?

Enactment Phase

18. Do you teach in accordance with what you have planned and agreed? Is there a strategy you follow for this?

19. How do you manage to adapt the lessons based on some requirements that might come from others?

20. How do you define the assessment criteria for the learning outcomes of your students?

21. What steps do you follow for assessing your students' learning outcomes?

Quality and Incidents Control Phase

22. Do you monitor your teaching against goals and plans that you have previously defined? If yes, how do you do?

23. If you monitor your teaching, do you also collect the results using a specific strategy? If yes, which is this?

24. Do you observe possible incidents that might occur during the teaching? How do you observe them?

25. After monitoring and collecting the results from teaching, do you analyze them? If yes, how?

26. Based on the results from the analyzation, do you plan some corrective action? How you do that?

27. Do you improve the teaching by revising the agreement and the curricula? Is there a specific way how you do that?

28. Do you improve the management of the environment and the technical infrastructure? How you do it?

29. Based on your reflection, do you improve your course aims and the plans? Which procedure do you follow?

30. Based on your reflection, do you improve your course materials and how?

31. Based on your reflection, do you change the methodologies for a better effect on students? How is this change made?

32. Do you do further training for improving your knowledge and teaching? How is this implemented?

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