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Theory-driven Design of an IT-based Peer Assessment to Assess High Cognitive Levels of Educational Objectives in Large-scale Learning Services

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THEORY-DRIVEN DESIGN OF AN IT-BASED PEER ASSESSMENT TO ASSESS HIGH COGNITIVE LEVELS OF EDUCATIONAL OBJECTIVES IN LARGE-SCALE LEARNING SERVICES

Research in Progress

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Abstract

Due to increasing numbers of students at German universities large-scale learning services are still a common default. These learning services lack interaction as well as feedback to assess learners' knowledge on the cognitive levels of educational objectives. This situation is alarming, since interaction and feedback in order to assess the own learning progress are important factors for individual learning success and satisfaction. The use of an IT-based peer assessment as a learning instrument can help overcome these challenges by increasing interaction and feedback without massively increasing the workload of lecturers. In this research-in-progress paper we present a theory-driven design of an IT-based peer assessment aiming to increase interaction and feedback as well as assess learners' knowledge on high cognitive levels of educational objectives in large-scale learning services. We follow a design science research approach and rely on insights from theory of interaction and feedback in order to gather requirements as well as derive design elements to create the IT-based peer assessment. As a next step, we will use the instrument in our large-scale learning service aiming to evaluate whether the IT-based peer assessment is useful to assess high cognitive levels of educational objectives, hence supporting learners during their learning process.

Keywords: Peer Assessment, Technology-mediated Learning, Educational Objectives, Design Science Research.

1 Introduction

Learning services, particularly in higher education at German universities, face increasing numbers of learners (Leidenfrost et al., 2009), especially due to the situation of double high school graduation classes in recent years (Wolter, 2014). This situation results in large-scale learning services with sometimes more than 100 learners per lecturer. These learning services are characterized by high anonymity and suffer from a lack of interaction - not only among learners themselves but also between learners and lecturers (Grießhaber, 1994). Moreover, getting individual feedback during the learning process is not feasible in traditional large-scale learning services, where learners are single learners (Lehmann and Söllner, 2014). This development is alarming, since fundamental elements of individual learning success include the opportunity to reflect the own knowledge (Gagné et al., 1993), to receive feedback on one's individual learning progress, and to have the possibility of sharing one's opinions concerning the subject matter (Picciano, 2002). Additionally, interaction and learning with peers are regarded as

significant predictors in terms of learning success (Moore et al., 1996) and positively influence the long-term satisfaction (Hardless et al., 2005, Alonso et al., 2009). Another challenge for large-scale learning services goes along with the complexity of the learning content. In order to understand the complexity of the learning content comprehensively, the learning content regarding knowledge transfer and knowledge verification should be aligned on the cognitive levels of educational objectives developed by Bloom et al. (1956). Modified by Anderson et al. (2001), the cognitive levels of educational objectives are as follows: *remembering*, *understanding*, *applying*, *analysing*, *evaluating*, and *creating*. In this paper, we rely on these cognitive levels of educational objectives. However, integrating knowledge transfer and knowledge verification concerning the high cognitive levels of educational objectives *(*namely *analysing*, *evaluating* and *creating)* to support learners in their learning process is difficult in large-scale learning services. While the learners would greatly benefit, the lecturer's workload would become intolerable. Knowledge verification of the high cognitive levels of educational objectives is characterized by assignments whose solutions are created by the learner and are very complex (e.g., extensive free text assignments, writing statements, and essays) (c.f. Mayer et al. (2009)). However, the knowledge verification of those assignments is time- and resource-consuming hence impossible to use in a large-scale learning service. Nevertheless, introducing interaction and feedback to assess educational objectives on high cognitive levels for individual learning success measurement during the learning process is a widespread problem. Since large-scale learning services lack time as well as human resources, the learners more often have to take over and control the learning process themselves (Delen et al., 2014).

Didactic mechanisms are needed in order to overcome the above mentioned factors characterizing traditional large-scale learning services. One promising possibility to enhance interaction and feedback and moreover to assess high cognitive levels of educational objectives without massively increasing the workload of lecturers is the use of peer assessment (Strijbos et al., 2009). By using peer assessment, learners evaluate the value or quality of another learner's or group's performance during the learning process (Topping, 2005), (Tahir, 2012) according to specifically defined criteria (Boud and Falchikov, 2007). Using a paper-based peer assessment is very time-consuming without any resource-saving manner (Sung et al., 2005), whereas the use of IT provides various potentials regarding the process automation, process tracking, and easy process editing (Davenport, 2013). Moreover, the use of IT allows the anytime-and-anywhere communication (Gupta, 2009). With the aid of IT, interactive data can be transferred between learners and lecturers in real-time, and the interaction can be improved (Dyson et al., 2009).

Hence, the use of peer assessment with IT support is a suitable learning instrument to support interaction and feedback and thus to assess knowledge on high cognitive levels of educational objectives. Learners will be supported during the learning process of a large-scale learning service without massively increasing the workload of the lecturer.

The goal of our research is to develop an IT-based peer assessment (ITPA) as a learning instrument to increase interaction and feedback during the learning process of large-scale learning services. Particularly, by using the ITPA, learners should interact more with the learning content, the lecturer, and among each other. Moreover, by participating in the ITPA, learners should assess their knowledge on the high cognitive levels of educational objectives during the learning process. Therefore, this paper aims to answer the following research question: How should an ITPA be designed to increase interaction and feedback and moreover to provide formatively learning success measurement concerning high cognitive levels of educational objectives?

2 Research Methodology

To achieve our research goal, we follow the design science approach (Hevner et al., 2004, Peffers et al., 2006), particularly the design science research approach of Peffers et al. (2006) (see Figure 1). We follow this approach because it offers an iterative approach for the development of artefacts. In our research we want to develop and to design the ITPA and subsequently, we want to evaluate the arte-

fact in a real problem situation and if necessary, make adjustments. Moreover, to ensure that the learning instrument ITPA addresses all important types of interaction, we follow Briggs' (2006) theory-driven design approach by grounding our research on theory on interaction and feedback. In this research-in-progress paper, we present details on the first three phases advocated by Peffers et al. (2006) for the development of the ITPA. The introduction has addressed the phase problem identification and motivation. Section 5 describes the objectives of a solution phase by identifying requirements from theory. We then provide in detail design and development of the ITPA, which is the third phase in the design science research approach. The paper closes with our next steps and expected contributions, focusing mainly on our planned demonstration and evaluation of the ITPA, which is expected to increase the interaction and feedback and moreover assess the learners' knowledge concerning the high cognitive levels of educational objectives during the learning process of large scale learning services.

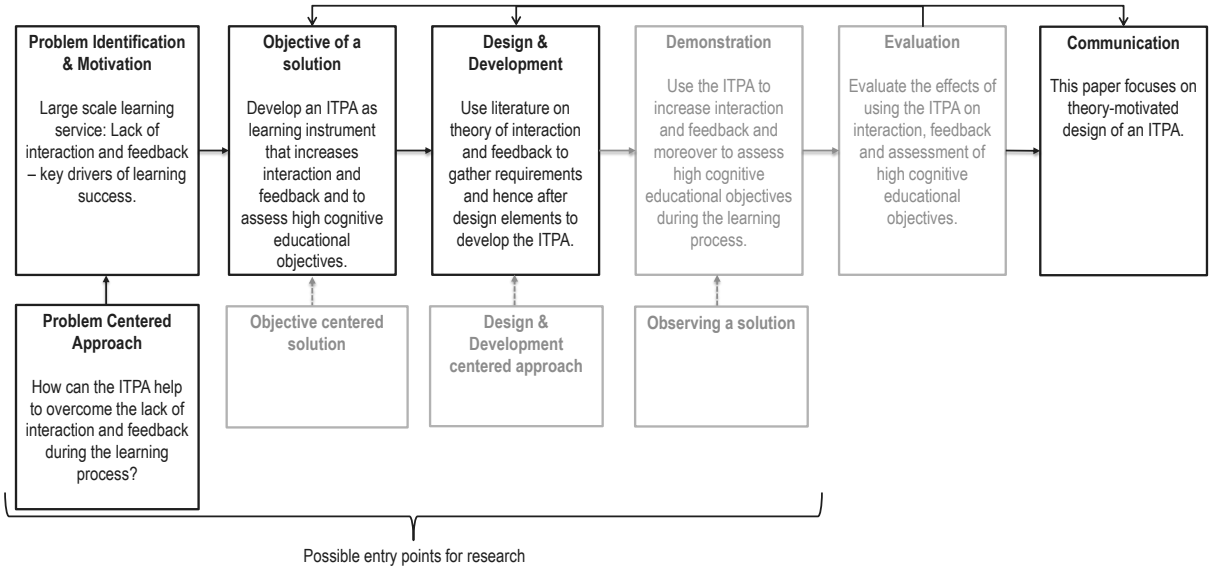

Figure 1. Research approach for developing the ITPA (shaded phases are not addressed in this research-in-progress piece). Source: Adopted from Peffers et al. (2006).

3 The Potential of Peer Assessment in Learning Services

Peer assessment allows for individual feedback on the learning progress as well as corresponding interventions by means of technical-based observation processes even in groups with a higher number of learners (Piech et al., 2013). It positively influences the peer learning process (Tseng and Tsai, 2007) and allows learners and lecturers to identify missing knowledge and misunderstandings not during the final exam, but rather early on. Giving feedback according to defined criteria is essential in order to support the feedback giver (Falchikov and Goldfinch, 2000). Scientific literature brings up terms such as peer assessment, peer evaluation, peer review, and peer feedback, among others (see Tahir (2012) for further details and definitions). In the present paper, we use the term of peer assessment to describe learners of a peer group in mutually evaluating each other's performance according to relevant criteria as well as formulating an overall feedback including strengths, weaknesses, and suggestions.

The idea of peer assessment is not only being applied in teaching. Pair programming is a common method in informatics, where software developers control each other's work and call attention to mistakes or complicated designs (Umar and Hui, 2012). In the field of science, scientists use peer review to assess other scientists' conference papers in order to ensure quality (Bauer et al., 2009). The application of peer assessment in learning services brings about, above all, the following advantages opposed to an evaluation solely done by the lecturer:

- Logistically: Lecturers can save precious time if learners give each other feedback and evaluate each other's academic performance (Sadler and Good, 2006).
- Pedagogically: The verification of responses according to correctness gives the learner a deeper understanding of the learning contents. By reading works of others, one can deepen one's own knowledge and develop new ideas by evaluating other points of view (Sadler and Good, 2006).
- Metacognitively: Learners will develop an awareness for their own strengths and weaknesses (Tahir, 2012) and will be able to compare and evaluate their own performance, at least to a certain extent (Darling-Hammond et al., 1995). In addition, learners train their abilities to think critically, as well as how to evaluate and reflect (Topping, 2005).
- Affectively: Learners perceive qualitative feedback from their peer group as more valuable than a lecturer's grade (Sadler and Good, 2006).

Therefore, the application of peer assessment does not only relieve the lecturer but turns learners into experts themselves.

Even if peer assessment enables learners for developing skills and a deeper knowledge understanding the use of peer assessment with support of IT comes along with some risks that need to be considered. Doiron (2003) indicates that using IT in peer assessment demands too much learner effort by putting too much pressure on them, that is not reliable, and that is not necessarily fair. Jaillet et al. (2009) alert the assessment doing by the peers can pose validity and reliability problems which calls for further investigation. Some studies emphasize learners' anxieties about the fairness and consistency of peer assessment (Cheng and Warren, 1997, Rushton, 1993). These critical facts need to be considered by evaluating peer assessment. Moreover, IT-use in learning services can result in frustration, confusion, and reduced learner interest (Hara, 2000, Maki et al., 2000). In online learning the learners must be highly self-regulated regarding their own learning because the lecturer can only influence the learning process to a small extent (Butler, 2003).

4 Related Work on Peer Assessment

First observations show that peers are indeed able to give valuable feedback (Dochy et al., 1999), (Falchikov and Goldfinch, 2000) and that evaluations done by the peer-group agree with the lecturers' evaluations of the learners' academic performances (Kulkarni et al., 2013). Furthermore, studies show that regular feedback given by the peer group has a positive effect on the learner's learning process (Dochy et al., 1999). In their literature overview, Van Zundert et al. (2010) point out that there are only a view existing case studies concerning an experimental setting of peer assessment and that this circumstance prevents specific insights on how peer assessment has to be designed. Depending on the individual design, peer assessment may take place orally or in a written form. Oral peer assessments usually provide face-to-face feedback. A written feedback may be paper- or IT-based (cf. Liu et al. (2003)) and can be given anonymously. The use of IT allows for a flexible usage. This way, peer assessment can take place synchronously, e.g., by means of chat programs (Sullivan and Pratt, 1996), or asynchronously (Tuzi, 2004), providing a benefit in terms of time management. Learners can invest the time they need for developing a solution or feedback for self-reflection or evaluation (Veerman et al., 2000).

5 Requirements from Theory of Interaction and Feedback

We employ a theory-driven design approach and therefore derive requirements from the theory of interaction and feedback with the aim to increase interaction as well as feedback and moreover to assess the knowledge on high cognitive levels of educational objectives. Therefore, we base our subsequent design decisions on the constructs linked to our phenomena of interest.

In the context of interaction as a part of learning, Moore (1989) formulates the most specific differentiation concerning the exchange with learning objects. He differentiates between learner-content-interaction, learner-lecturer-interaction, and learner-learner-interaction. We adopt these three types of interaction for our research and define interaction itself as learning activities, including exchange between learners, lecturers, and content (Schrum and Berge, 1997). Prior research has shown that learners who interact with their lecturer are more actively involved in the learning process (Wang et al., 1990) and receive better results in the final exam compared to those who don't interact with others. Thus, the lecturer can actively involve the learner in the teaching process, assess the learning progress by means of correct or incorrect answers, and give direct feedback. The learners have the possibility to share own ideas and thoughts and thus provide new thought-provoking impulses (Gagné et al., 1993). A study shows that learners with low or intermediate previous knowledge profit from a high degree of interaction and achieve higher learning results (Snell, 1999). An interactive setting can enhance learners' motivation and participation in class, as well as foster greater learners' exchange (Liu et al., 2003, Sims, 2003).

Besides interaction, feedback is essential to foster learner's learning process and to demand the application with the learning content (Tahir, 2012). The relevance of feedback during the learning process is in line with receiving feedback on one's own performance as well as providing feedback on another learner's performance. When receiving and providing feedback, the improvement of the reflection ability is of great importance (Bauer et al., 2009), especially in terms of self-regulated learning (Butler, 2003). Ertmer and Newby (1996) point out that feedback on one's own performance leads to an awareness and understanding of how to control the own learning. In practical terms, many learners do not reflect on their own learning process (Van den Boom et al., 2007).

Thus, it is very relevant to integrate didactic mechanisms in a large-scale learning service and to emphasize learners as a central part of the learning activities. The three types of interaction represent the starting point for deriving requirements. The realisation of interaction enables receiving and providing feedback regarding the high cognitive levels of educational objectives. Table 1 presents the requirements (R) we could identify from theory. These are the basis for developing the ITPA. Requirements formulation is based on Pohl et al. (2010).

Interaction type	Description	Requirements
Learner-Learner-Interaction	The learner-learner-interaction takes place between one learner and others, alone or in group settings, with or without the real-time presence of an lecturer (Moore, 1989). It is described as an extremely valuable resource for the individual learning (Moore, 1989). Learners should be encouraged to cooperate with the peers during the learning process for working together to exchange knowledge (Boud et al., 1999) and discussions among each other (Alavi et al., 2002) to enhance motivation (Eisenkopf, 2010) and learning success (Fredericksen et al., 2000, Moore and Kearsley, 2011). This interaction type is not effectively facilitate in large-scale learning services and calls for specific didactic mechanisms or IT use (Phillips et al., 1988).	R1) Learners should cooperate with the peers during the learning process. R2) Learners should work together to exchange their knowledge among each other. R3) Learners should communicate among each other.
Learner-Lecturer-Interaction	In this type of interaction, the lecturer attempts to achieve teaching aims regarding the curriculum or the learning content (Moore, 1989). Moreover, the lecturer seeks to enhance the learner's interest, including self-direction and self-motivation (Moore, 1989). The lecturer still plays a significant role for learning success as well as satisfaction (Eom et al., 2006). Lectures should give advice and feedback to learners and need to retain an overview of the learners' performance (Bligh, 1998). In addition, the lecturer should verify which educational objectives have been achieved or may not have been achieved. In interaction with lecturers, learners can request clarification of unclear points and lecturers can reinforce correct interpretation (Thurmond and Wambach, 2004).	R4) Learners should have the possibility to ask questions regarding unclear points. R5) Learners should get feedback on the individual performance. R6) Learners should give feedback on an individual performance. R7) Learners should be informed about specific educational objectives.

Learner-Content-Interaction	This type of interaction contains what Holmberg (1986) calls the "internal didactic conversation" when learners "talk to themselves" regarding the learning content and ideas they encounter from the learning material (Moore, 1989). Moreover, this interaction form takes place when learners examine the course content (Moore and Kearsley, 2011) and take part in class activities (Thurmond and Wambach, 2004). Learning materials should be designed in an activating way to support peer learning and it should be developed with regard to instructional and multimedia design guidelines (Clark and Mayer, 2008). The learner should reflect the own performance and think critically on the own solution to a specific assignment (Leung et al., 2014).	R8) Learners should get content specific assignments in an activating way. R9) Learners should be able to reflect and think critically regarding their solution to a specific assignment.

Table 1. Derived Requirements from Theory.

6 Design Elements for the ITPA

In order to increase interaction over all interaction types during the learning process integration of didactic mechanisms are needed where we use ITPA. For a theory-driven deduction of design elements we use peer assessment as theoretical basis (Lehmann et al., 2014). Based on the requirements derived from theory we formulate design elements concerning the identified requirements as theoretical foundation for the ITPA (see Table 2). The design elements are based on the well-known principles of good practice (Chickering et al., 1987). The wording is addressed to the lecturer who is responsible to integrate didactic mechanisms.

Requirements	Design Elements (D)
R1) Learners should cooperate with the peers during the learning process.	D1) Create assignments where learners cooperate among each other.
R2) Learners should work together to exchange their knowledge among each other.	
R3) Learners should communicate among each other.	D2) Create assignments where learners communicate among each other.
R4) Learners should have the possibility to ask questions regarding unclear points.	D3) Integrate discussions and questions in the classroom that learners interact with the lecturer and other learners.
R5) Learners should get feedback on the individual performance.	D4) Create assignments where learners formatively get individual feedback on their learning progress.
R6) Learners should give feedback on an individual performance.	D5) Give learners criteria to evaluate each other's performances.
R7) Learners should be informed about specific educational objectives.	D6) Design assignments regarding the cognitive levels of educational objectives.
R8) Learners should get content specific assignments in an activating way.	D7) Ensure that learners learn continuously during the learning process. D8) Create complex assignments which forces learners to interact with the learning content.
R9) Learners should reflect and should think critically regarding their own solution to a specific assignment.	D9) Give learners criteria to self-assess their own solution on a specific assignment.

Table 2. Derived Design Elements for the ITPA.

7 Application of the ITPA

The concept of the presented ITPA will be implemented in a blended learning introductory IS learning service, which is designed as a flipped classroom (Oeste et al., 2014). We designed the flipped classroom as a learning cycle, repeating five times during one semester. Each cycle comprises four individual consecutive phases. The first phase can be substituted as self-learn via video- and script-based

learning units, as well as additional web-based trainings. The second phase (peer learning) consists of free text assignments to be solved as individual. The found solutions serve as input for phase 3 (collaborative clarification), which is held in presence. The intention of this phase is to answer comprehension questions as well as eliminate misunderstandings from the first two phases with the lecturer by means of discussions. Additionally, the lecturer presents the previously submitted solutions of the free text assignments from phase 2 and emphasizes on relevant content strengths and weaknesses. Phase 4 is held in presence by means of a tutorial. Here, the learners acquire the learning content in small groups.

The ITPA will apply in phase 2, namely the peer learning phase, as well as in phase 3 for discussions of the solutions (Lehmann et al., 2015). The use of ITPA aims to support the peer learning process by means of receiving and providing feedback, as well as increasing interaction between learner-learning content, learner-learner, and learner-lecturer. Furthermore, the ITPA as learning instrument means to assess learners' knowledge on high cognitive levels of educational objectives. Hence, learners will receive as well as provide feedback on high cognitive levels of educational objectives. In the following, we describe the ITPA process and present how we integrate the derived design elements into the ITPA.

The free text assignment for the ITPA will require depth of content in order to develop solutions, the combining of learning contents, as well as the finding of own arguments. The goal is to address the high cognitive levels of educational objectives according to Anderson et al. (2001) (namely *analysing*, *evaluating*, *creating)*. With the creation of the free text assignment we implement the design element D6. The university's learning management system (LMS) Moodle with the workshop module will be used to support the peer assessment. Thereby, we use an existing platform and adjust the settings regarding our needs. A schedule will set certain deadlines, with each deadline instructing the learners what to do exactly in what time frame. Additionally, short videos will explain how to use the workshop module in the LMS in order to avoid operational problems. Furthermore, the learners will be reminded to solve the remaining task before each deadline. In a first step, each learner has to solve the free text assignment individually before anonymously uploading it to the LMS, which then automatically distributes the individual solutions to the peers. By solving a free text assignment individually, the design elements D7 and D8 are implemented. The peer assessment is designed as 1:5 assessment, meaning that each solution will be evaluated by five different peers and each learner will provide feedback on solutions by five fellow students. The goal will be that each learner's effort to provide feedback remains maintainable while guaranteeing each learner diversified feedback. So far, no relevant research concerning the necessary number of feedback providers ensuring valuable and diversified feedback from peers comparable to a lecturer's feedback has been conducted. This concludes additional possible research.

The ITPA is designed completely anonymously. No learner is aware whose solution they were evaluating or whom they will receive feedback from. This way, the feedback is more precise, valuable, and honest (Bostock, 2000) and avoids the influence of social relationships on the feedback (Boud and Tyree, 1980), allowing for content-based, objective feedback. On the one hand, each feedback provider is supposed to evaluate each solution's strengths and weaknesses and to give suggestions for improvement. On the other hand, each feedback provider is supposed to give feedback according to the quality of the solution and the author's expertise. The defined criteria comply with Bauer et al. (2009). The rating sheet is complemented by own criteria for assessing the knowledge on the high cognitive levels of educational objectives. By means of the rating sheet for providing feedback, the design element D5 is implemented. Moreover, each learner is going to make a self-assessment of the own performance regarding the solution of the free text assignment. This implements the design element D9 and will be realised via an online questionnaire tool. The provided feedback needs to be uploaded to the LMS by a certain deadline. After receiving the feedback, each learner has to revise their solution accordingly. Receiving the feedback addresses the design element D4. Moreover, the ITPA allows asynchronous cooperation and communication among the learners themselves, which addresses the design elements D1 and D2.

During the phase 3 of the flipped classroom learning cycle, held in presence, the lecturer will present several solutions of the free text assignment and emphasize on relevant content strengths and weaknesses. Via the LMS, the lecturer has access to all results. Relevant questions and misunderstandings will be answered during a moderated discussion. This increases the interaction between the learners and the lecturer as well as among the learners themselves and addresses the design element D3. Eventually, the lecturer will provide a best-practice-solution for the free text assignment. This ensures that each learner can compare their own solution to the best-practice. Moreover, this enables each learner to assess their own knowledge regarding the high cognitive levels of educational objectives (addressing D4).

The figure below schematically illustrates the ITPA process:

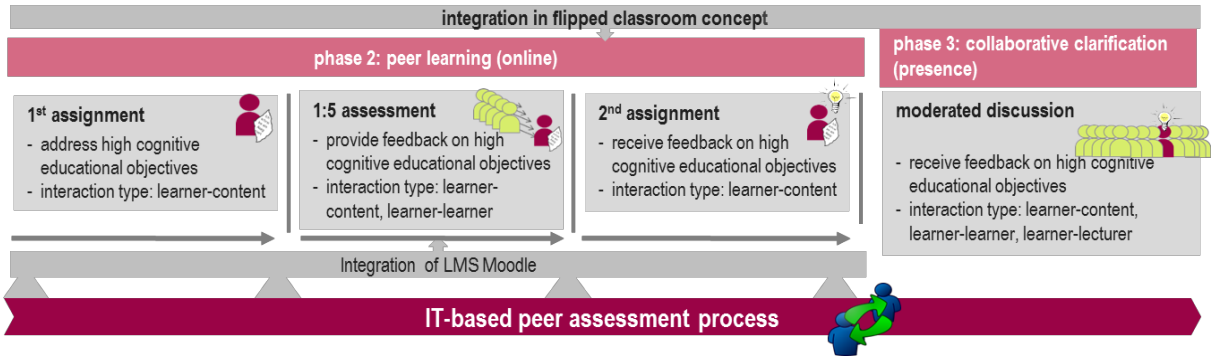

Figure 2. ITPA process including addressed interaction types per phase.

8 Next Steps and Expected Contribution

Since our design for the ITPA process is finished, we plan to use the ITPA in the current winter term in an IS introductory learning service with 250 undergraduate learners. The participation on the ITPA won't be mandatory, but rewarded with extra credit. During design science research the intended (and unintended) impact of the design artifact needs to be scientifically evaluated to show utility, quality and efficacy (Hevner et al., 2004). One goal will be to determine the effectiveness of the ITPA in terms of interaction and feedback. The second goal is to examine the ITPA as learning instrument for individual learning success measurement to assess the educational objectives. The third goal will be to determine ITPA's utility using UTAUT (Venkatesh et al., 2003). The quantitative evaluation will be realised over a questionnaire including necessary items according to scientific literature and will be adjusted to relevant research context when necessary. Additionally we want to collect qualitative data over the online questionnaire to gather possible improvements for ITPA design. Using the ITPA in our learning service and to comprehensively investigate the ITPA as per description resembles the demonstration and evaluation phases of Peffers et al.'s (2006) design science research process. After the comprehensive evaluation of the ITPA, we expect to be able to show whether the ITPA is useful in terms of increasing the interaction of large-scale learning services. Moreover, we expect to demonstrate whether the ITPA is a suitable learning instrument for individual learning success measurement to provide feedback to the learners concerning high cognitive levels of educational objectives.

The results are of scientific and practical relevance in terms of education, since they provide insights on how to integrate interaction and feedback into the learning process by means of peer assessment, and at the same time antagonizing the challenges of large-scale learning services. The presented ITPA considers the roll of peers. Thus, the results contribute to the didactical theories of IS research by providing insights on a learner-oriented approach integrating interaction and feedback into large-scale learning services. The results can also be applied to further teaching-learning-environments.

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