An Interactive Pool of Exercises for Individual Learning Support in Academic Courses

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Abstract: The use of multi-media and Internet in academic courses steadily increased in the last two decades gaining improvements in teaching in various respects, and leading to the well-known fields of e-learning and blended learning. Especially large courses can greatly benefit from new technologies which, however, require initial installation and permanent management effort. In this paper, we present an e-learning approach called *Interactive Pool of Exercises (IPE)* which requires little effort to establish and manage. It is particularly well-suited (but not limited) to provide learning support for students in large courses. The IPE is built as a connection of a pool of course-related exercises and an online forum. Every exercise is bi-directionally linked to a corresponding thread in the forum, the linking being achieved by standard Internet and PDF technology only. We present the technological background of the IPE and give installation recommendations, and we perform an evaluation of the students' acceptance of the IPE as well as an analysis of their learning improvement.

Introduction

E-learning is still growing rapidly in popularity and it is a pervasive element of higher education today (Shivetts 2011, Rovai 2004). Ten years ago the main goal of e-learning was its integration into distance or virtual universities (Schulmeister 2001). However, within the last few years e-learning became more and more appealing for "brick and mortar" universities, too. There, known under the term *blended learning*, a mixture of classic face-to-face teaching and online techniques is usually applied. The reason for this development is mainly attributed to the following potentials that offer an enhancement to classic classroom courses (Schulmeister 2006):

1. Improvement of teaching and encouragement of self-study.
2. Enhancement of assistance between two attendance lectures.
3. Control of the amount and the actuality of the educational material.
4. Independence of time and place.

It is stated that addressing the teaching of courses with the involvement of blended learning is a complex and serious issue which leads to the fact that faculty members avoid teaching blended learning. Therefore a systematic blended learning design is desirable. (Garrison 2004)

Depending on the target audience, particularly with respect to the number of participants and their degree of diversity, different tools and techniques may be appropriate. Furthermore, Shivetts (2011) states that student motivation is a major factor for the success of e-learning and blended learning. It is still challenging to choose the appropriate e-learning tools for a given course which, on the one hand, are accepted by students and lecturers, and, on the other hand, gain an improvement over classic teaching. Furthermore, an important issue is that the techniques should be realizable with suitable effort.

In this paper, we present an e-learning tool called *Interactive Pool of Exercises (IPE)* which can be set up and managed easily using standard (Internet) technology only. The IPE consists essentially of a collection of course-related exercises which are bi-directionally connected to a separate thread in an online forum. This enables students to repeat, tighten and apply the lecture and tutorial material on the basis of a pool of exercises as well as to discuss the material covered in lecture, tutorial and the pool.

Learning techniques can be dependent (synchronous) or independent (asynchronous) of time and place (Rosenberg 2006). The IPE expands the face-to-face lecture, and a supporting face-to-face tutorial, both essentially synchronous, with an asynchronous learning tool.

Due to the bi-directional connection between exercises and discussion threads within the IPE, users can quickly switch between a question and the corresponding exercise in the pool simplifying the asking and answering process compared to a regular discussion forum. Furthermore, the advisors can follow the discussions gaining information about the knowledge state of the students, and address problems individually. This is typically difficult in large courses. The IPE additionally serves as a knowledge archive, filled by students and advisors, which is similar to a wiki. This leads to a decrease of required advisor interventions over

a semester and over the years. Overall, the effort which the advisors have to put into the development and management of the tool considerably decreases over time. The online discussion forum additionally suits the demand of talking and writing about lecture topics which is known to increase knowledge gain (Markel 2001, Ellis et al. 2004).

So far, the IPE has been applied and studied in a computer science course during one lecture period with a rather large target audience (about 580 students), cf. Section "Evaluation", however, it is in principle applicable to smaller courses, too. The evaluation indicates that by this rather basic tool which does not require any heavy-weight e-learning technologies, the acceptance of online forums on both, the student and the advisor side as well as the skills learned by the students has improved significantly.

Related work

In a survey of the use of Web 2.0 technologies in higher education during the time span from 2007 to 2009, Liu et al. (2012) found that the most commonly studied technologies in the literature were blogs, wikis, podcasts, social networks, and virtual environments. The authors examined a total of 143 papers, but were not able to answer one of their major research questions: "Is there any research evidence that Web 2.0 technology can enhance teaching and learning?"

Valdes-Corbeil (2008) states that among the major concerns of users confronted with the idea of using Web 2.0 technologies in teaching are: (1) the required skills for setup and management are (too) high; (2) privacy might be difficult to obtain; (3) SPAM might be a problem; (4) the invitation of guest speakers to a blog might be difficult. Wang (2008) adds to these the common concerns against wikis that there might be a low "accuracy of the content and rigidity of scholarship in a wiki". These concerns, although being more or less easily invalidated, are less of a topic when using more conventional technologies.

Furthermore, Selim (2007) points out that the inexperience of students with e-learning technologies can be a problem when introducing new tools. With the use of standard Internet technologies, all these disadvantages can be avoided.

Shin and Lowes (2008) study how the experience with Web 2.0 and social presence in the web affect the behaviors of users in online discussion forums. They suggest that these aspects do not affect participation at all; however, they state that active Web 2.0 users tend to lead online discussions. Furthermore, they conjecture that particularly younger people use Web 2.0 and, therefore, lead online discussions more actively. This is an advantage in typical academic courses which consist primarily of young people.

Richa et al. (2011) present an algorithm to predict knowledge gain of students by analyzing their discussion patterns within an e-learning environment. Using this information, the students are classified through a Naïve Bayes Classifier into "gainers" and "non-gainers" of the platform, and the authors suggest strategies to improve the non-gainers' learning progress.

Goals of the IPE

It has to be stressed that the IPE is not supposed to be a sophisticated high-level e-learning tool, but rather a simple method which can be used with little effort in courses that are otherwise designed in a more classic way.

The IPE in its current version arose from a need of providing the students of an upcoming course (in October 2011) quickly with a set of exercises. Due to the numerous additional exercises, it was a premise to create a possibility to discuss exercises in an easy-to-manage online forum. Altogether, the following goals arose:

1. Increase the number of exercises to improve course-related practical training.
2. Offer the students the possibility to ask questions independent of time and place.
3. Conserve the students' questions and answers given by the lecturers or fellow students in a knowledge database in a preferably structured way.
4. Provide a simple tool to keep track of all questions and answers during the semester accessible by students and lecturers.
5. Simplify the question-asking and answering process to save student and lecturer time.
6. Provide a tool which can easily be supplemented with further exercises as well as ported to different platforms and adapted to different courses.
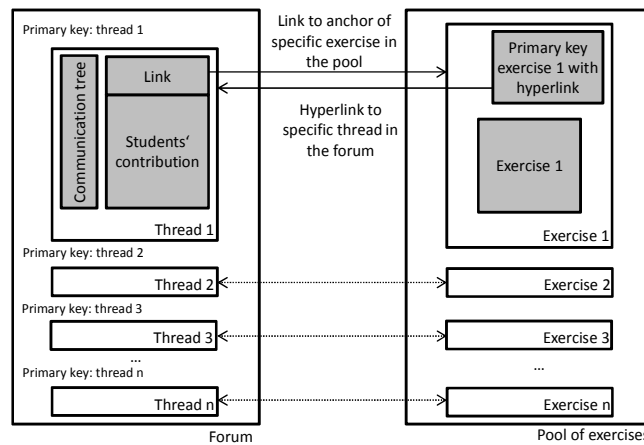
Structure of the IPE

The IPE consists of (1) a *pool of exercises (PE)*, and (2) an *interconnected forum (IF)*, cf. Figure 1.

The PE: As shown in Figure 1-right, the exercise component of the IPE is basically a single document containing a list of exercises. To accomplish the bi-directional linking, the PDF file format has been used. PDF offers, on the one hand, a possibility to introduce hyperlinks pointing to web addresses (threads of the forum), and, on the other hand, an anchor functionality which can be used to jump to a specified position in a document.

The latter functionality is used to jump from a thread in the forum to the corresponding position in the document. For the IPE, the document was created using Latex. Both, hyperlinks and anchors can be included in a fairly simple way using the Latex `hyperref` package and the commands `\href` and `\hypertarget`, respectively. The documentation of these commands can be found on the web and is not explained here in detail. However, the idea of the IPE is not limited to using Latex, but can be established in a technically simpler way by putting each exercise in a single file, thus avoiding the need for anchors. Hyperlinks can also be included without the use of Latex using MS-Word, for example. For interacting with the forum, a primary key is assigned to each exercise in the pool which has an underlying link to the according thread in the forum. Each primary key is additionally connected to an anchor in the PDF document. The primary key is used as an internal identification, and it is shown to the users in the names of the threads and at the beginning of each exercise. This makes it possible to manually navigate between PE and IF in addition to the automatic linking. The number of exercises is flexible and can be adjusted permanently according to demand. The students can choose between two different views, one consisting of the tasks assignments only, the other additionally displaying solutions.

The IF: The forum itself is a typical online forum which contains one thread for every exercise in the pool. The students are not allowed to create new threads as the global structure is given by the PE. Within each thread, the students can establish the usual discussion trees. The view including solutions can be accessed via a link to the corresponding exercise which jumps directly to the correct position in the IPE. The version without solutions is not accessible automatically, but has to be examined manually using the primary key.

Figure 1 – Structure of the IPE. Right: layout of the *pool of exercises (PE)* containing *n* exercises; left: layout of the *interconnected forum (IF)* with corresponding threads and a communication tree; bi-directional linking illustrated by arrows.

Realization of the IPE

The IPE was first introduced for continual assessment for second year students of the course *"Foundations of Informatics II"* ("Grundlagen der Informatik II"; *FI-II*) within the degree program "business engineering" in the winter semester 2011/2012 (lasting from October 2011 until February 2012) at the Karlsruhe Institute of Technology (KIT). The tool has been offered in addition to a regular weekly lecture reading and an accompanying tutorial. An additional aspect is that the lectures are recorded and available to students right after the live lecture.

The PE: The pool contained during its usage phase 121 exercises which were approximately uniformly spread over the course topics. The exercises were developed with the aid of former student tutors, and reviewed by the lecturers to assure coverage of the course topics and adequate exercise types and formulation. Moreover, the exercises were classified into three groups, namely "easy", "medium", and "difficult". A screen shot of an exercise with its corresponding primary key ("REC-AA") is shown in Figure 2-right.

The IF: The forum consisted of 122 threads (cf., Figure 2-left), 121 of which corresponded to the exercises as described above. One additional thread called *correction history thread* was used by the lecturers to announce changes in the PE, for example, after the correction of errors. The forum itself is based on the first open-source learning management system "Ilias", which was developed at the University of Cologne (Henning et al. 2007). Ilias is not required to set up the IPE, but it was integrated in the learning infrastructure at the KIT for the last decade, therefore, students and teachers are familiar with it. However, it offers some beneficial properties, most importantly the possibility of forbidding the creation of new threads to students. Furthermore, all users have to join a lecture group to be allowed to post messages which makes it possible to evaluate the

usage statistics afterwards. The postings are still anonymous, so no backtracking to the authors of possibly "stupid" questions can be performed. The 122 threads and an initial posting to each have been created by an administrator. The initial posting is highlighted and contains the hyperlink "to the exercise" ("Zur Aufgabe"; cf. Figure 2-middle). This is a natural compromise to the question of who should start a discussion thread, student or lecturer (Mazzolini and Maddison 2007): It is up to the students to ask questions, but the discussion structure is given by the lecturer.
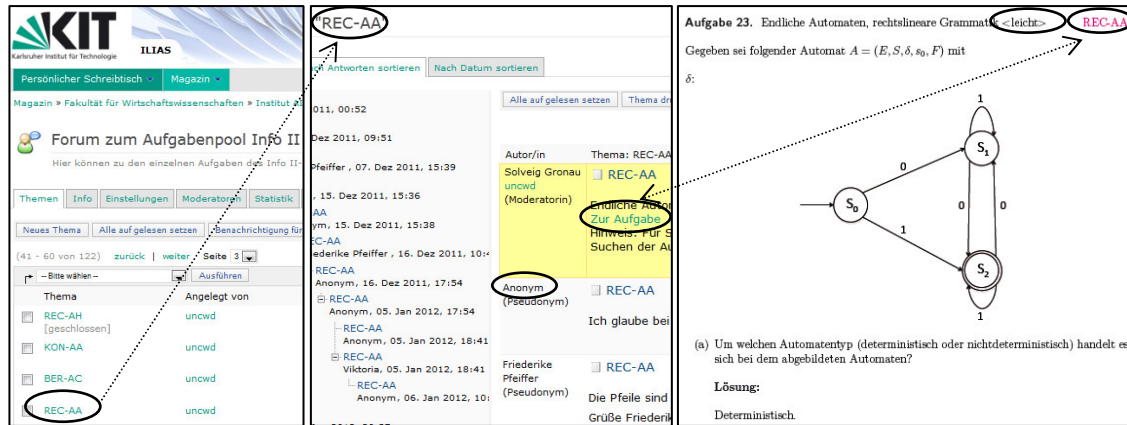
Figure 2 – Collection of screenshots of the IPE. Left: forum with primary key "REC-AA" as an example; middle: REC-AA thread with anchor link "to the exercise" ("Zur Aufgabe"), highlighted initial posting and "anonymous" ("Anonym") student posting; right: exercise with difficulty level "easy" (<leicht>) and highlighted primary key with hyperlink to the corresponding thread REC-AA.

Evaluation

Scenario and Methodology

This section describes the teaching environment of the IPE and the methodology of evaluation.

Evaluation Period: The IPE has been used in a regular teaching situation for the first time during winter semester 2012 in the course FI-II; this time span is called the *utilization period (UP)* in the following. The data collected from the UP is compared to data from the according courses given in the winter semesters 2003 to 2011; this time span is called the *control period (CP)*. The UP and the CP together are called the *Evaluation period (EP)*.

Boundary conditions during the EP: The course covers a rather broad range of topics from theoretical computer science (part I) and the architecture of computer systems (part II). Due to its theoretical nature, the course content was kept nearly constant during the EP. The number of students attending the course ranged from 450 to 600 students who were mainly in the third semester of their diploma or bachelor study, respectively. In addition to 135 minutes of lectures per week which were provided online after each lecture, the students were offered accompanying tutorial courses (90 minutes every two weeks) given by student tutors. In the tutorial courses, 46 exercises covering the topics of the course were solved under the guidance of a tutor. An online general-purpose forum was available to the students for discussion of any course-related topics with fellow students and the lecturers as well as a weekly offered face-to-face question time. In the general-purpose forum the students were able to start new threads themselves. The students were graded mainly by a written *final exam* (90 minutes) at the end of the course (mid-February). By another, smaller exam called *bonus exam* (45 minutes), performed in mid-January and covering the topics of the first part only, the students got the chance of improving their final grading by one predefined small step. All lectures in the UP were given by the same professor except for the semesters 2004 and 2009 (due to sabbatical terms). For the organization of the lectures and tutorials, two assistant lecturers were employed (in 2005 only one). The tutorials were given by 15 to 20 student tutors. Both the assistant lecturers and the tutors changed over the years; however, one of the current assistant lecturers is in charge since 2008, the other since 2011.

Structural changes from CP to UP: Except for the introduction of the IPE, for the first time two overview lectures have been given in 2012 by the assistant lecturers, each at the end of the respective part of the course. Other than these, there were no considerable changes to the structure and organization of the course.

Introduction of the IPE: The IPE including the forum and all exercises was completely new to the students and has not been used in earlier years. As the IPE was not completed at the beginning of the semester, it was introduced in mid-November. The exercises were given to the students in addition to the exercises presented in the tutorials. In addition to the IPE forum, the general-purpose forum was still available.

Methodology of evaluation: The IPE is evaluated in the following respects.
1. Statistical evaluation:
   a. UP vs. CP: the results of the final exam 2012 are compared to those from the CP.
   b. Within UP: the usage statistics of the IPE are analyzed, and the individual utilization of the IPE is related to the according exam results.
2. Subjective evaluation:
   a. Students' opinions (as stated within common course evaluations regulated by university guidelines) are presented.
   b. Lecturers' observations are discussed.

The evaluation is done along the four perspectives mentioned above as potentials of blended learning:
1. Improvement of teaching and encouragement of self-study.
2. Enhancement of assistance between two attendance lectures.
3. Control of the amount and the actuality of the educational material.
4. Independence of time and place. (Schulmeister 2006)

Statistical analysis: Most of the presented data is normally distributed. If so, standard deviation (*SD*) is given to indicate spreading and a two-tailed Student's *t*-test is performed to prove statistical significance in the difference of mean values.

Results – Statistical evaluation

UP vs. CP: We first compare the results of the final exams of the last 10 years to find out if the last year (UP) indicates a significant difference in student knowledge. We assume that the students' intelligence and previous knowledge of the course topics, and the difficulty of the exams on average did not change significantly in the EP.

Some key characteristics of the past ten exams are shown in Table 1. The average number of students participating in the exams within the EP is 473.8 with a rather low SD. The maximum reachable score of the exams was 90; the minimum score to pass the exam was 40.5. The average maximum reached score is 85.8 over the last ten years. The highest score reached overall in the last years is 89.0 in 2004, this year's value being slightly lower (88.0 points). The minimum reached score in the UP is by far the highest reached in the EP (mean 4.55; SD 7.63). This drift in the UP is also reflected by the values of the average score of 60.94 (mean 53.17; SD 4.26) and the pass rate of 97.10% (mean 82.65%, SD: 8.45%). The pass rate is with a confidence close to 95% (difference to mean: 14.45%, SD: of 8.45%) different from the mean.

	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	mean	SD
number of students	517	406	402	541	433	465	426	461	493	594	473.8	59.28
max. reached score	88.0	86.0	85.5	85.0	85.5	87.0	82.0	84.5	89.0	85.5	85.8	1.83
min. reached score	24.5	0.0	0.0	0.0	0.0	2.0	0.0	0.0	11.0	8.0	4.55	7.63
medial score	60.94	52.94	59.26	51.94	52.28	54.07	45.68	51.45	54.62	48.48	53.17	4.29
pass rate	97.10%	87.93%	91.29%	83.18%	83.37%	83.44%	69.48%	80.91%	82.15%	67.68%	82.65%	8.45%

Table 1 – Key characteristic data of past ten exams. Reachable score was 90; minimum score to pass was 40.5. Highlighted boxes indicate highest value for the corresponding line.

The key characteristics of the UP exam in comparison with the ones of the CP suggest that the results of 2012 are based on a different normal distribution than the ones in the CP. Table 2 shows the key characteristic values from the UP and the mean values form the EP and CP with the corresponding SD. By comparing the SD of the EP (2003-2012) with the one of the CP (2003-2011) it can be stated that all SDs from the EP are significantly larger. Therefore, we conclude that the values of the UP (2012) are based on a different normal distribution.

	UP	EP	SD	CP	SD
max. reached score	88	85.80	1.83	85.56	1.77
min. reached score	24.5	4.55	7.63	2.33	3.94
medial score	60.94	53.17	4.29	52.30	3.60
pass rate	97.10%	82.65%	8.45%	81.05%	7.32%

Table 2 – Key characteristics of 2003 to 2012 (EP) and 2003 to 2011 (CP) in comparison with the values form 2012 (UP). The comparison of the EP with the CP shows a divergence in terms of SD.

Figure 3 shows the two different normal distributions based on the data of the UP and the CP, respectively. The density functions as well as the data from the final exam of 2012 and from the CP are illustrated in Figure 3–left. The corresponding distribution functions are plotted in Figure 3–right.

The density function and the distribution function of the normal distribution based on data from 2012 in comparison with the ones based on data from 2003 to 2011 show the expected movement. The density function of 2012 is shifted to the left side which accounts to a higher medial score (UP: 60.94, CP: 52.30). Therefore, the slope of the distribution function is steeper at the beginning of the curve and more even beginning at about a score of 50. The SD of the two curves shows also significant differences with 11.98 (UP) and 15.10 (CP). This means that the spread of the exam score over the maximum of 90 is in the CP higher than in the UP. This is also illustrated in Figure 3-left by the fact that the density function of 2012 has a higher peak and is less spread whereas the density function of 2003 to 2011 is smoother and wider spread.
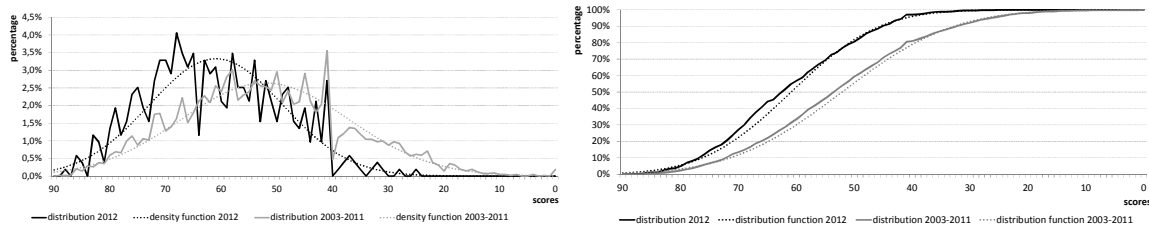
Figure 3 – Normal distributions based on UP and CP. Left: density function and data distribution for 2012 in black, for 2003-2011 in grey; Right: distribution function and corresponding data for 2012 in black, for 2003-2011 in grey.

For finally verifying that the results of the CP are more similar than the ones of the UP, a two-tailed Student's *t*-test is applied by comparing the results of the different exams with each other. Table 3 shows the result of this analysis.

	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
2012	100.00%									
2011	0.00%	100.00%								
2010	5.68%	0.00%	100.00%							
2009	0.00%	27.51%	0.00%	100.00%						
2008	0.00%	51.21%	0.00%	71.46%	100.00%					
2007	0.00%	24.22%	0.00%	1.56%	6.64%	100.00%				
2006	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%			
2005	0.00%	12.70%	0.00%	57.77%	39.86%	0.56%	0.00%	100.00%		
2004	0.00%	9.29%	0.00%	0.34%	2.02%	57.41%	0.00%	0.12%	100.00%	
2003	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.39%	0.16%	0.00%	100.00%
	2012	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**

Table 3 – Student's *t*-test for mean scores of all years compared with each other. The table entries show the probability for the H_0 hypothesis that the corresponding two mean values are equal.

The results show that the exams of the years 2011, 2009, 2008, 2007, 2005 and 2004 are most similar (yellow in table). Of the *t*-test values of this group, ⅔ lie significantly over 5%. The final exams of 2003 and 2006 were two outliers as the scores lie clearly below the ones of the other years. The mean value of the results of 2010 is with a probability of 5.68% the same as the mean of 2012 (blue in table). This value is still rather low so it seems legitimate to decline the H_0 hypothesis that the results of 2010 and 2012 have the same mean value.

Within the UP: As demonstrated above, the exam of 2012 reached significantly better results than the ones before, but it is still not clear how the IPE contributed to this development. Figure 4 compares the results of the students who were active in the forum with those who were not active. "Active" means in this context that they registered for the use of the IF. Note that the use of the PE can be done without any registration.

446 students were active in the forum in the above sense, 381 of who also participated in the final exam. 136 students who wrote the final exam were not active in the forum. The black curve in Figure 4 shows the results of the 381 active students, the grey one the results of the remaining 136 students. The comparison of the two curves suggests that they are not based on the same normal distribution. The corresponding *t*-test which is shown by Table 4 also indicates this. The *t*-test states that with less than 0.6% probability the mean value of the two normal distributions is the same. This strongly suggests that the students which used the complete IPE performed better than the ones who only used the pool of exercises. However, as Figure 4 shows, even without being active in the forum the students perform better in 2012 than in the years 2003 to 2011. We attribute this to the use of the PE.

	with IPE	without IPE
num. of students	381	136
mean	61.78	58.58
SD	12.15	11.22
t-test	0.56%	
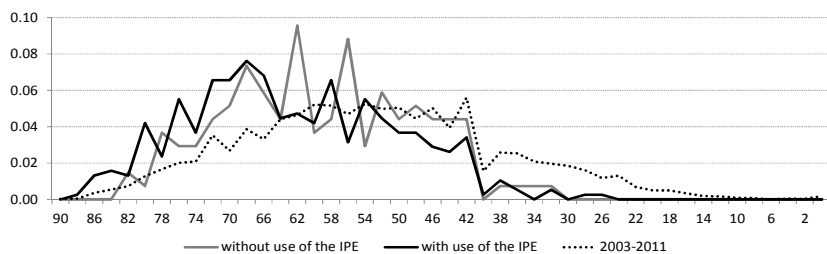
Figure 4 – Comparison of "active" (i.e., registered for the forum) with "non-active" students' results. The black graph shows the relative distribution of the students who used the IPE; the grey graph shows the ones without the use of the IPE, respectively. For comparison, the dotted line shows the mean results of the CP.

Table 4 – Student's *t*-test for the use of the IPE. With less than 0.6% probability the mean of the scores "with IPE" equals the mean of the scores "without IPE".

The statistical analysis of the forum shows the contribution to the students' success in the final exam in comparison with results of the years before. The statistics indicate that the IPE achieved the "improvement of teaching" (1) and "enhancement of assistance between two attendance lectures" (2).

Results – Subjective evaluation

Students' opinions: As stated in Section "Realization of the IPE", the forum contains 122 threads. Table 5 shows some key usage statistics of the forum.

number of postings	1,135	number of visits	10,625
max number of postings / thread	43	max number of visits / thread	428
min number of postings / thread	1	min number of visits / thread	1
medial number of postings / thread	9.30	medial number of visits / thread	87.09
medial postings / participant	2.71	medial visits / participant	25.41

Table 5 – Key data extracted from the forum. The left column shows the data corresponding to the postings; the right column presents the data regarding the visits.

At the end of lecture period 2012 (UP) the forum comprised 1,135 postings and was 10,625 times visited overall (cf. Table 5). On average, each of the 418 participants wrote 2.71 postings and visited the forum 25.41 times.

The comparison with the general-purpose forum of the last four years (cf. Table 6) shows a considerable gain of students' participation. The mean of the number of threads from 2009 to 2012 is 154.5 and the number of postings is 620.75 on average. The use of the forum lies with 4.05 postings per thread on average significantly below the use of the IPE with 9.30 postings per thread. Moreover, the absolute number of threads and postings increased from 2011 to 2012.

	forum 2012	forum 2011	forum 2010	forum 2009	mean
number of threads	201	165	126	126	154.5
number of postings	790	629	552	512	620.75
medial number of postings / thread	3.93	3.81	4.38	4.06	4.05

Table 6 – Usage of the general-purpose lecture forum 2009 to 2012. For comparison, key characteristics are given.

This comparison demonstrates that the offer of the IPE increases the "enhancement of assistance between two attendance lectures" (2) and that this offer is also accepted by the students. Besides, this proposal of the IPE also contributes to an increased use of the general-purpose forum by 165 threads in 2011 to 201 in 2012 and 629 postings to 790, respectively. The higher number of postings is not directly a proof for a learning improvement, but it can be seen as an indication.

The analysis of visits in connection with postings is illustrated in Figure 5. A more individual analysis of the distribution of postings and visits of the participants is impossible due to the anonymous character of the forum. The highlighted outlier corresponds to the correction history thread which comprehensibly was visited by the students most frequently. This indicates that the students aspire to an opportunity to keep the lecture and teaching materials up to date. The figure illustrates that the number of visits increases with the number of postings. The students have the desire for a "control of the amount and the actuality of the educational material" (3). This actuality and control is given by the correction history thread.
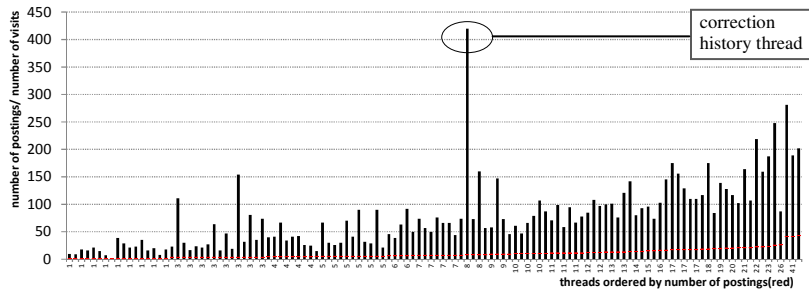
Figure 5 – Connection of postings and visits to threads of the forum, ordered by the number of postings. Black bars show total number of visits per thread; red markers display the number of postings per thread (which also count as visits).

The high number of discussion threads with more than nine postings indicates that serious discussions took place with contribution to deep learning (Mazzolini and Maddison, 2003). A subjective inspection of the forum confirms this statement. However, this does not necessarily mean that threads with fewer postings are inefficient.

A key feature of an e-learning tool is, as mentioned above, the "independence of time and place" (4). One goal of the IPE was to offer the students the opportunity to discuss and ask questions at any time. The data shows that the students seized this occasion. Figure 6 shows the timely distribution of postings discretized to one hour.
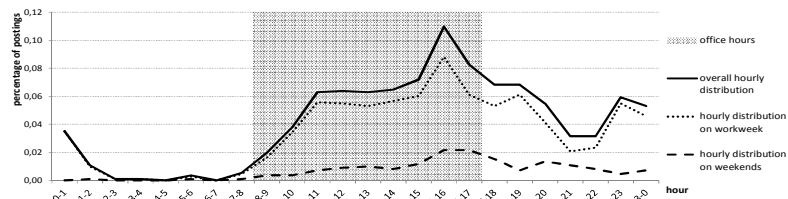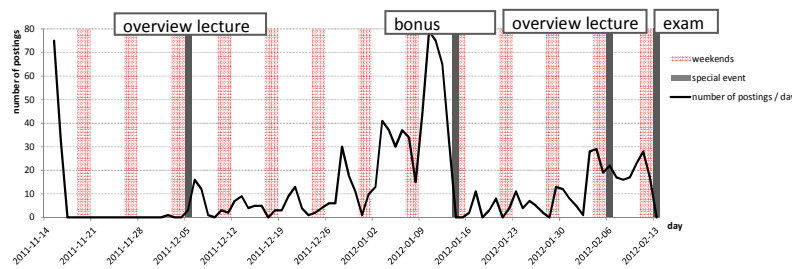

Figure 6 – Timely distribution of postings. Grey area shows the office hours (8am to 5pm), the line graphs indicate the hourly distribution of postings. The black line shows the overall distribution; the dotted line represents the distribution from Monday to Friday; the dashed line shows the distribution on Saturdays and Sundays.

It can be seen that the students used the IPE most frequently during office hours, but also regularly in the evening hours. The usage of the pool on weekends is also important. Table 7 shows the data regarding the use of the IPE during labor time (weekdays 8am to 5pm) and leisure time (weekdays 5pm to 8am and weekends) in absolute and relative terms.

	number of postings	percentage
labor time	545	48%
leisure time	590	52%

Table 7 – Usage of IPE divided into labor and leisure time. The usage is presented in absolute and relative terms.

More than 50% of the postings have been written in leisure time. Thus, the IPE fulfills the perspective of "independence of time"; as the students have everywhere access to the IPE the "independence of place" is also met.

Figure 7 – Number of postings per day. Red areas indicate weekends, grey bars mark special events during lecture period.

The timely distribution of postings over the days of the semester is shown in Figure 7. The introduction of the IPE on 2011-11-14 is indicated by a high number of postings which correspond to the initial postings by an administrator. The first peak after the first overview lecture shows that the lecture encouraged students to concentrate on their learning. The increase of the number of postings per day before the bonus exam indicates that the students require assistance especially before exams. The massive decrease of interest between the bonus

exam and the final exam came to us as a surprise. We accounted it to the fact that the number of unanswered questions declined as more and more questions were already answered. Of course, it is possible that the first part of the lecture led to more questions than the second part, however, as both parts were relevant for the final exam, this cannot completely account to the decrease. The statistical analysis of the forum showed that the "enhancement of assistance between two attendance lectures" (2) and the "independence of time and place" (4) as well as the "control of the amount and the actuality of the educational material" (3) are achieved by the IPE.

Last, the IPE is assessed by the subjective opinions of the students and the lecturers. During each lecture period two evaluations with specifically designed questions (e.g. adequate lecture material, lecture speed, etc.) are performed for the tutorials and the lecture separately. The evaluations are done at about two thirds of the lecture period. The students give grades between 1 (best) and 5 (worst). Table 8 shows the comparison of the results of the evaluations after lecture period 2011 and lecture period 2012. The number of participants of each of the four evaluations is displayed in Table 8 as well as the average rating.

lecture	medial num. of participants	medial rating	tutorial	medial num. of participants	medial rating
2011	285.42	2.47	2011	159.78	2.31
2012	402.77	2.29	2012	239.57	2.07

Table 8 – Statistical data of the evaluations in 2011 and 2012. Statistical data of the lecture (left) and of the tutorial (right).

The two graphs in Figure 8 show the results of the evaluations of the tutorials (left) and the lecture (right) of the years 2011 and 2012, respectively. The evaluation for the tutorial is based on 23 different questions on the x-axis and for the lecture on 26 questions. The graphs indicate for the lecture and especially for the tutorial that the overall movement is positive regarding the rating of the students. The evaluation of the tutorial only shows two outstanding outliers in the middle which do not follow this trend: the questions asked for "the essential amount of work" and the "adequacy of this amount of work". We accounted this to the subjective feeling of the students that with the IPE the required effort for this course is higher although the lecture material did not change. The corresponding questions in the lecture evaluation displayed by the peak at the same position on the right follow this effect only slightly. It is surprising that the students' rating of the "the essential amount of work" is worse than the rating of the one in 2011, but the "adequacy of the amount of work" was rated better in 2012. This can be explained by the fact that the students implicate the IPE in the context of the tutorials, but not in the lecture. All the other ratings for tutorial and lecture follow a positive trend or are very similar to the ones of 2011.
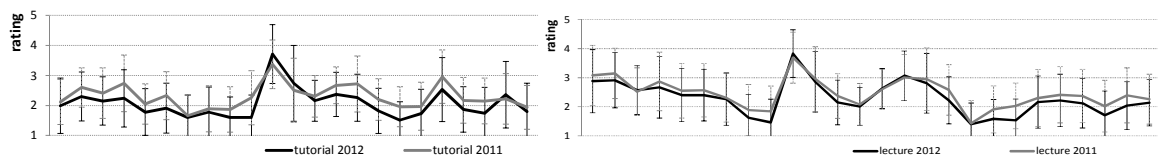
Figure 8 – Evaluation results of tutorial (left) and lecture (right) of 2011 and 2012. The grey lines show the results of the evaluations in 2011; the black lines display the evaluation results of 2012 with the corresponding SD, respectively.

Lecturers' opinion: From the lecturers' (i.e., authors') perspective, the IPE offers particularly the following three benefits. (1) The students' learning progress and main problems are easier to observe and to address. Furthermore, individual students can be treated in a more customized way according to their special needs. (2) The forum (IF) serves as knowledge archive which, over time, contains more and more answers to common student questions. Therefore, it can be assumed that the IPE can particularly be used from year to year with decreasing effort as fewer questions have to be answered. Up to now, there is no data over several years of usage confirming this assumption. However, a significant decrease of the number of questions from the time before the bonus exam to the time before the final exam indicates that the need for lecturer assistance shrinks over time. Additionally, the great success of Internet platforms like Wikipedia which archive knowledge in a similar way supports this statement. Furthermore, the uniform structure of the forum and the pool of exercises provides for a naturally ordered knowledge data base which can be accessed easily based on relevant exercises. (3) The public accessibility of the forum allows for discussions between all users of the forum, particularly within course participants and between course participants and tutors. This can lead to a better understanding of the discussed topics due to a common knowledge background of the students. Moreover, the answering process can be distributed on several shoulders and is not left completely to the teachers. Based on our experience, the course participants themselves provide for a rather small amount of answers in the forum. However, the tutors could be well incorporated in the answering process, particularly handling a great amount of rather facile topics.

A main disadvantage of the IPE is the initial and permanent management effort. However, due to the exclusive use of standard technologies, the initial operations took a few days only (omitting the effort for creating the exercises). The management effort has been rather high as many questions had to be answered by the lecturers. Also, there has been a (nonrecurring) need for correcting some of the exercises during the semester which also increased the management effort. However, as stated before, we assume that the management effort will significantly decrease in future.

Conclusion and Future Work

In this paper, we presented an Interactive Pool of Exercises (IPE), which was developed in 2011 for the second-year Bachelor course *"Foundations of Informatics II"* at the Karlsruhe Institute of Technology. The IPE was used as an e-learning tool in addition to the regular lectures and tutorials. It is composed of a collection of course-related exercises and a forum, bi-directionally connected to each other. Every thread in the forum corresponds to one exercise.

The IPE has been evaluated from two major directions, a statistical evaluation of the results of final exams of the last ten years, and an analysis of subjective students' and lecturers' opinions. The statistical evaluation showed that there is a significant improvement in this year's exam compared to the past years' exams. Furthermore, a *t*-test analysis showed that students using the IPE performed significantly better than students of the same course without using the IPE. The students' acceptance of the forum is considered positive regarding the number of postings. Moreover, a significant decrease in the number of participants of face-to-face offers has been observed, e.g., during a weekly offered question time. The independence of time and place was of high importance as more than 50% of the postings took place outside the office hours. The goal of keeping track of all questions and answers led to the result that the number of questions was reduced over time. Official lecture evaluations by the university as well as an informal lecturers' opinion show wide acceptance and agreement of the IPE.

In future, the amount of postings and educational material as well as their actuality will be controlled and supplemented. Furthermore, we intend to reuse the already created forum filled with contributions of this year's students in the next years to find out if a decrease in student's questions will occur as conjectured. Moreover, we want to study the influence of giving participants an opportunity to rate exercises for the benefit of future readers.

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