The Use of an Audience Response System to Monitor Students’ Knowledge Level in Real-time, Its Impact on Grades, and Students’ Experiences

Margit Kastner
Vienna University of Economics and Business
margit.kastner@wu.ac.at

Abstract

In an effort to evaluate the effectiveness of an audience response system (ARS), a mixed methods approach was developed using qualitative and quantitative questionnaire data together with direct measures such as exam and ARS performance scores. The results reveal that students’ exam scores are higher for those students who answer ARS questions and that ARS performance scores are an indicator of how well a student will do in the final exam. Furthermore, perceived usefulness and perceived enjoyment matters for the grade, while anxiety and self-efficacy do not have an impact on students’ achievement. Qualitative data on students’ ARS experiences provide even deeper insights into the ARS itself and its implementation in the course, ARS questions and their benefits, and students’ emotional associations. Finally, students who did not answer ARS questions had the opportunity to comment on their reasons for non-participation.

1. Introduction

After decades of research on teaching and learning, the empirical support for the benefits of active learning is extensive. Using active learning techniques in class, students’ performance improves significantly compared to traditional lecturing [17]. Thus, a shift from teacher-centered to more interactive, student-centered teaching techniques can be recognized [6]. To foster active learning, especially with large class sizes, audience response systems (ARSs) are increasingly adopted at educational institutions across the world [28].

An ARS, a technology as seen on television (e.g., Who Wants to be a Millionaire?), enables an instructor to post a question and instantaneously collect the answers from a big audience who use (mobile) devices to respond. Immediately afterwards the instructor can tally the anonymous responses and project them onto a screen. Moreover, several ARSs allow tracking the individual responses for further usage.

In the educational context, ARSs are utilized to increase course attendance [10], to enhance student interaction, engagement, and attention [10, 27, 28], to stimulate in-class discussion [27, 28], to assess students’ comprehension of the learning content, to correct misconceptions [11, 27], to allow students to apply their knowledge [11, 31], to reflect on what they learned and to internalize it [11, 19, 31]. In addition, instructors use ARSs for formative and summative assessments [27]. Students report higher enjoyment in classes with ARS usage than in classes without [11, 46], enhanced learning [25], and improved short- and long-term knowledge [47]. For these reasons, students favor ARS usage [25, 47] and instructors highlight that the application of an ARS perfectly complements other teaching methods [39].

To date, research on ARSs in the context of education is comprehensive, but the state of current research on ARS is still in the fledgling stages. In fact, the majority of studies tends to concentrate on anecdotal explanations [27]. Thus, several shortcomings can be noted. First, studies suffer from methodological flaws. Most quantitative studies lack, for instance, validity and reliability tests of the measurement instruments [27], even if a new instrument is developed [21]. In turn, the methodology section of qualitative studies is often either missing or ambiguous [27]. Therefore, such studies can be criticized for subjectivity resulting in correspondingly weak explanations. For example, studies explicitly examining students’ attitudes toward ARSs have thus far only presented positive replies [46]. Second, previous studies fail to examine the benefits and challenges of applying ARSs for summative assessments [28]. Third, results on the effects of ARS usage on test scores are controversial. While some scholars observed a progress in exam performance [7, 49], others found no improvement in grades [29, 46] or no effects on fail rates after the introduction of an ARS [29]. Forth, despite a thorough literature review, no papers on the reasons for not responding to ARS questions were detected.

To address some of these shortcomings, the present study aims to gain deeper insights on the basis of the following research questions: (1) Does the application of an ARS improve students’ test performance? (2) What factors have an impact on students’ test
performance? (3) What are students’ experiences in using an ARS? (4) What are reasons for not answering ARS questions?

2. Hypotheses development and research model

**Perceived usefulness** is widely applied. It suggests that a system that is able to assist or help individuals is more useful [9]. Students’ common notion is that ARSs are helpful [e.g. 7, 11, 29], and previous studies have demonstrated that systems which are believed to be useful facilitate higher performance [26, 37]. Furthermore, lecturers acknowledge that ARSs are useful to enhance learning [14] and to keep up to date with learning [13], which in turn would suggest a better ARS question performance. From these observations the following hypotheses are drawn:

H1: Perceived ARS usefulness has a direct positive effect on perceived ARS learning enhancement.

H2: Perceived ARS usefulness has a direct positive effect on ARS question performance.

**Perceived enjoyment** is a person’s perception of how much fun s/he is having when undertaking an activity such as using a system [48]. Regarding ARSs, several scholars [e.g. 18, 50] provide evidence that students enjoy their usage. This is essential because previous research highlights the significance of enjoyment in an educational context [23]. Others [e.g. 11, 46] report that lectures applying ARSs are more enjoyed than courses relying on traditional teaching approaches. Enjoyment, being an intrinsic motivator, enhances students’ learning success [30], which in turn should be reflected in a better ARS question performance. Students further emphasized that ARSs contribute to their learning experience and overall understanding of the learning content [18, 25, 50]. A positive effect of enjoyment on learning enhancement is thus not only identified by Kastner [25], but also assumed in this study. In consideration of above arguments, it is proposed:

H3: Perceived ARS enjoyment has a direct positive effect on perceived ARS learning enhancement.

H4: Perceived ARS enjoyment has a direct positive effect on ARS question performance.

**Self-efficacy** is generally understood as a person’s belief in her/his own ability to successfully complete an assignment or to achieve a desired objective [5, 40]. Self-efficacy provokes that students work harder [5]. It is not only found to be an indicator of success in technology-assisted education [2, 26], but also for training outcome in general, as supported by various meta-analyses [e.g. 8, 45]. Students afflicted by self-doubts often create failure scenarios. Hence, it is difficult for them to achieve their goals [5]. In essence, the hypotheses deduced are:

H5: Self-efficacy has a direct positive effect on ARS question performance.

H6: Self-efficacy has a direct positive effect on students’ grades.

**ARS question performance** is hardly documented because ARSs are mainly used to collect formative feedback rather than scores [28]. Looking at participations reveals that students who had participated in answering ARS questions attained higher examination results than nonparticipants [18]. Additionally, the more often they participate [18] and give correct answers [10], the higher their grades. Research on summative assessment evaluating the usage of short-answer and multiple choice questions during the lecture brought to light that such short tests are a good means to enhance retention and to improve the subsequent performance in exams [35]. Thus, it is suggested that questions posed by ARSs work similarly. This leads to the following hypothesis:

H7: Students’ ARS question performance is positively associated with students’ grades.

**Learning enhancement** is reported by several studies evaluating ARSs. ARS usage leads to a better understanding of the content [11] because of applying and reflecting what has been learned [11, 31], and due to the possibility to correct misconceptions [11, 27]. Students agree that ARS question usage in class helps them prepare for exams [4]. Nevertheless, in a blended learning design it is demonstrated that enhanced learning experiences resulting from the incorporation of group discussions and interactive learning activities into the course do not lead to an improvement of students’ examination results [34]. However, since students proved rather enthusiastic about ARS usage and its learning benefits [38], it is even proposed:

H8: Perceived learning enhancement has a direct negative effect on students’ grades.

**Anxiety** is an unpleasant state individuals experience in testing situations [43]. In fact, most of us feel nervous when facing an exam, but this is even helpful to stay focused and to study harder. Extreme fear, however, badly affects performance [8], because it makes it difficult (or impossible) to concentrate and to recall things one has studied and known before the test. In relation to the above literature, the following hypothesis is concluded:

H9: Test anxiety has a direct negative effect on students’ grades.

To round out this chapter, the suggested research model comprising all hypotheses is displayed (Figure 1).
3. Methodology

3.1. Research setting and ARS used

This research examines the ARS usage in four Marketing courses taught over the period of a year. In total, approximately 820 students enrolled, although neither course enrollment nor attendance were a prerequisite to take the exam. Hence, course attendance is decidedly lower than actual course enrollment.

The courses provide students with an understanding of basic marketing concepts and feature a blended learning design, combining online learning and face-to-face instructions. For online learning, students can access a variety of resources through the university’s learning management system (LMS), such as an online textbook, exercises, mock exams, or video interviews with marketing experts. Regarding the face-to-face instructions, all courses have the same setting: Each classroom is equipped with fixed seats in auditorium-style. The lectures start on Wednesday at 8:00 a.m. and last for three hours at a time. The same female instructor teaches all courses. She has many years of experience in lecturing as well as in creating reliable multiple-choice questions, and she regularly enriches her lectures with multi-media applications such as videos, current ads, and ARS questions.

In each unit, the instructor poses four to six questions with the goal to help students recognize how the various marketing concepts are interrelated and to encourage them to apply their knowledge. In the first unit, students have the opportunity to familiarize themselves with the ARS. In the following units, the students receive credits for correctly responding to the questions. These credits serve as a bonus to be added to the exam scores, and can thus enhance a student’s total points by 2.5%.

The applied ARS is a browser-based mobile ARS. It is an in-house development of the university. Built on the OpenACS component of the XoWiki Content Flow package [1], it is integrated into the university’s LMS. For the compilation of ARS questions, the instructor first logs on to the LMS. Then, only a few easy-to-follow steps are necessary to generate multiple-choice questions with up to five answer alternatives, and to publish them. In class, the lecturer informs the students when to answer a question and displays the question onto a screen. This holds the advantage that the questions fit the content and that additional, more complex questions including videos can be asked (see Figure 2). Besides, a red-tinted notification button in the banner of every page of the LMS indicates the number of pending questions yet to be answered by students using their mobile devices (e.g. smartphone, tablet, or laptop). After the login, a click on the red-tinted button takes them to the pending question. Then, they simply select an answer and click on “Send”. As soon as all students have sent their answers, the instructor unpublishes the question and projects the anonymized results in form of a pie chart onto the screen. Finally, the instructor provides immediate feedback and discusses all (in)correct answer alternatives with the students in detail. On top of that, the ARS records each student’s individual response (see Figure 2 “Submission list”). This allows to monitor the students’ knowledge and understanding and to assign credits for correct answers, thus also encouraging students to take the polls more seriously. Students without access to mobile devices may hand in their answers on paper in order to collect bonus credits.

3.2. Measures

For the purpose of answering the research questions, this study uses a mixed methods approach comprised of students’ grades and ARS question performance as well as qualitative and quantitative data collected by means of an online questionnaire.

At the end of the course and before the exam, a questionnaire is used to evaluate ARS usage and students’ experiences with the system.
a thoroughly conducted literature review. Items of self-efficacy are borrowed and adapted from the work of Pintrich [41] and anxiety originates from Driscoll [12]. Perceived usefulness is measured using the items from Davis [9], while the measurement of perceived enjoyment and perceived learning enhancement originate from Igbaria et al. [24] and Sprague & Dahl [44], respectively. In the questionnaire, students were also asked for permission to combine the collected data with their grades and ARS question performance. This was approved by the students entering their registration number. Since all items were adjusted to the ARS context and translated into German, the questionnaire needed to be pretested. In doing so, firstly, two independent researchers provided feedback on the translated questionnaire. Secondly, 25 participants were recruited to complete the questionnaire and comment on the clarity of the questions, comprehensibility, language proficiency, and lenience to answer. Thirdly, the comments were critically reviewed by the research team. Since only minor corrections needed to be done, the pretest did not have to be repeated.

To review the students’ achievement, student’s Marketing grade without consideration of the ARS scores (bonus points), measured on a 100-point scale, were obtained. In addition, each student’s score gained by answering ARS questions correctly were collected. This was approved or, in case of disagreement, recoded and highlighted for further discussion. In addition, higher levels of abstraction, i.e. categories, were built to make better sense of the data. In the third stage, the first and a third analyst each received the revised coding list and the proposed categorizations. As a next step, another analyst rechecked the codes by revisiting the original data. That way, the individual codes were approved or, in case of disagreement, recoded and highlighted for further discussion. In addition, higher levels of abstraction, i.e. categories, were built to make better sense of the data. In the third stage, the first and a third analyst each received the revised coding list and the proposed categorizations. As a next step, another reevaluation round of the coding list took place. Finally, the three analysts discussed all controversial codes and categorizations in order to understand the similarities and differences in their interpretations and to generate the final categorization.

4. Results

4.1. Sample description

In total, 564 students participated in the study, out of which 196 did not answer the ARS questions. This leaves 368 students who answered the ARS questions. Among the 564 participants, 47.8% are female and 52.2% are male. Their age lies in the range 18 to 56 years (mean=21.92) and the students’ mother tongue is mainly German (83.9%). To determine whether the sample is representative of the university’s student population, \( \chi^2 \) goodness-of-fit tests were carried out. They provide evidence that the sample’s gender distribution does indeed match that of the students at the university (\( \chi^2 = .016, p = .900 \); for male students: \( \chi^2 = .014, p = .906 \)). The same holds true for the distribution of students from German speaking countries and international students (\( \chi^2 = .044, p = .834 \); for international students with another mother tongue: \( \chi^2 = .207, p = .649 \)). Since not all students provided their registration number and some did not take the exam despite having
attended the course, the number of participants dropped to 263. In this cohort of the sample, students’ gender is almost evenly divided (50.6% are male and 49.4% are female). Participants are between 18 and 56 years old (mean=21.0) and 80.6% speak German as their mother tongue. Once more, χ² goodness-of-fit tests confirm the sample’s representativeness.

4.2. Students’ performance

A Spearman’s correlation test is performed to determine whether students benefit from ARS usage. As shown in Table 1, the findings reveal that there is a significant correlation between the points attained at the exam and ARS usage (p=.027). This indicates that students who answer ARS questions have better grades.

<table>
<thead>
<tr>
<th>Points achieved</th>
<th>No ARS usage</th>
<th>ARS usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 50</td>
<td>8.6%</td>
<td>7.0%</td>
</tr>
<tr>
<td>51 – 60</td>
<td>12.9%</td>
<td>11.7%</td>
</tr>
<tr>
<td>61 – 70</td>
<td>27.6%</td>
<td>20.7%</td>
</tr>
<tr>
<td>71 – 80</td>
<td>33.6%</td>
<td>35.2%</td>
</tr>
<tr>
<td>81 – 90</td>
<td>15.5%</td>
<td>19.9%</td>
</tr>
<tr>
<td>91 – 100</td>
<td>1.7%</td>
<td>5.5%</td>
</tr>
</tbody>
</table>

4.1. Antecedents to students’ performance

To assess the CMB, the Harman’s single factor test and the inspection of the correlation matrix are applied. The Harman’s single factor test extracted five distinct factors with an eigenvalue greater than 1. These five factors together account for 74.47% of the total variance, the largest of which only constituting 36.65%. This suggests that CMB is an unlikely threat because no single factor accounts for the greater percentage of the explained variance [42]. According to the inspection of the correlation matrix, no correlation is above the threshold of .90 [3]. Consequently, there is evidence that the CMB is no reason for concern in this study.

Prior to testing the SEM, a CFA assessed construct validity and reliability of the measures. The goodness-of-fit indices exceed the optimal levels suggested by Hu and Bentler [22] with TLI .987, CFI .990, RMSEA .033, and SRMR .027. Thus, the measurement model fits the data appropriately. The item loadings of the constructs are between .735 and .897, and therefore well above .50 as suggested by Hair et al. [20]. The CR values of all items in the study, ranging from .823 to .939, and Cronbach’s alpha values, ranging from .823 to .890, exceed the recommended threshold of .70 (see Table 2) [16, 36]. For the AVE, acceptable levels are 0.5 or higher [16]. As shown in Table 2 (see diagonal entries), all constructs meet this criterion. Taken together, the three measures “item loadings”, “CR”, and “AVE” thus provide evidence of convergent validity. The results presented in Table 2 also confirm discriminant validity because all AVE values (diagonal entries) are greater than the squared correlations (off-diagonal entries) [16]. Overall, the proof of reliability, convergent validity, and discriminant validity suggest that the measurement model is satisfactory for the testing of the structural model as a subsequent step.

<table>
<thead>
<tr>
<th>α</th>
<th>CR</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-efficacy</td>
<td>.890</td>
<td>.939</td>
<td>.738</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enjoyment</td>
<td>.823</td>
<td>.895</td>
<td>.048</td>
<td>.650</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usefulness</td>
<td>.886</td>
<td>.936</td>
<td>.049</td>
<td>.413</td>
<td>.724</td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>.865</td>
<td>.922</td>
<td>.003</td>
<td>.072</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning Enhancement</td>
<td>.881</td>
<td>.934</td>
<td>.055</td>
<td>.434</td>
<td>.719</td>
<td>.052</td>
</tr>
</tbody>
</table>

Note: AVE is reported on the diagonal.

The examination of the structural model reveals that the data fits the model rather well. The TLI is .985 and the CFI is .988. Thus, both range above the required level of .90 [22]. With a RMSEA of .032 and a SRMR of .029, they are at sufficient levels, too (i.e. RMSEA and SRMR < .05 [22]).

The results of the structural model (see Figure 3) indicate that both perceived usefulness of the ARS and perceived enjoyment of the ARS activity are positively related to perceived learning enhancement due to the application of the ARS. Perceived ARS usefulness is also connected to the scores students achieved by answering ARS questions correctly, whereas perceived enjoyment is not. As hypothesized, the relationship between perceived learning enhancement and students’ grades is negative, while ARS question performance affects the final grades. Surprisingly, self-efficacy and anxiety are irrelevant, as they do not have the hypothesized impact on students’ ARS scores and/or grades.

4.2. Students’ ARS experience

In total, 313 students provided 855 statements on their experience with the ARS. As shown in Table 3, student comments are of quite a different nature. Some of them refer to the ARS itself and its implementation in the course (89 mentions). Others address ARS questions (166 mentions) and the perceived extrinsic and intrinsic benefits gathered from their usage (304 mentions). Comments also deal with the feelings students ascribe to the system or its application (296 mentions).
First of all, more positive than negative comments were provided. However, students’ remarks on the system and its implementation in the course are rather critical. They often claim that the time frame is short and that one is forced to attend the course at unfavorable hours. Another concern is that no bonus points can be attained in case of being unable to attend the lecture. Consequently, alternatives to gain bonus points at home such as homework or online participation are specified. Yet, other students feel encouraged to attend the course. Apart from that a few students experienced problems handling the ARS as they point out that application is cumbersome, while for others usage is straightforward.

Students recognize that ARS questions are designed to allow the application of their knowledge to real life situations and to combine different subject areas. Furthermore, the integration of supportive elements such as videos or photos are named. Questions are perceived as well-thought-out, however, featuring sometimes seemingly imprecise phrasing. Being of different levels of difficulty, some students find them too simple, while others state that they are challenging or even too difficult. However, adequate difficulty is stated, too. With regard to responding to ARS questions, students need to be quick. They often work in teams to find the correct answers or consult their learning material. It is also stated that the knowledge of marketing theories and concepts as well as getting prepared for class are important prerequisites for answering the questions. Alternatively, guessing or copying from peers are the only options left to be employed by some students.

Participants mentioned two different kinds of extrinsic benefits. First, bonus credits are named. Whereas some students appreciate that they can earn bonus credits, others find that the credits awarded are not enough. Second, ARS questions are answered to get a better, or at least a positive grade. Intrinsic benefits are related to learning and engagement. The learning benefits stated most often are: repetition, knowledge monitoring, training/practice, self-test, enhancement of understanding, exam preparation, and stimulation to consult the book. Engagement benefits addressed include the encouragement of participation and discussions, the motivation to keep up to date with learning, stimulation of attention, course attendance, and encouragement to get involved. However, two negative statements are found in the context of benefits. One student felt that ARS questions draw off attention and another student considered the stimulation poor.

Upon examination of the students’ emotional associations, it turned out that there is a 3:1 ratio of positive to negative comments. On the positive side, students express that the ARS is useful, interesting, a nice change, a good idea, funny, exciting, positive, beneficial, entertaining etc. Negative associations evoked by the ARS are stress, time pressure, uselessness, confusion, or annoyance.

All themes and the respective frequency of mentioning are presented in Table 3.

4.3. Students’ causes for ARS non-participation

207 statements were provided by 178 respondents, expressing their rationales for not answering ARS questions. Their reasons are manifold. Based on a content analysis, six different categories are identified (see Table 4). Remarks related to mismanagement are the ones most often mentioned (82 mentions). This means that they either did not know about the opportunity to answer ARS questions (63 mentions) or they only realized it when it was already too late (10 mentions). Some participants also stated that they had no access to the ARS questions (8 mentions). A closer look revealed that these participants did not attend the lecture. ARS questions are activated for only a few minutes and they are not shown in detail in the ARS (i.e. each ARS question including answers appears in detail only on a slide in class). This implies that students at home hardly have the chance to participate or they need to take wild guesses. Relating to this, many students commented on the non-attendance category (67 mentions). A few participants gave reasons for not attending the course such as missed enrollment, the early start of the course, or unfavorable times in general. 34 annotations are related to time constraints, which – of course – is related to the prior category. No time was brought up most often (17 mentions), followed by the obligation to attend another course (9 mentions) or to work (4 mentions). In total, twelve disutility factors are pointed out, comprising e.g. no interest, no or too little bonus credits, useless, time-consuming, and negative cost performance ratio. External factors received twelve mentions. Within this category, students mentioned that taking the exam was a short-term decision for them or that they rather study on their own. Lastly, two mentions refer to the risk category, with students bringing up anxiety to answer ARS questions.

5. Reflection of the study results

5.1. Discussion and implications

The study was designed to determine the effects (1) of ARS application and (2) other factors (see Figure 1) on students’ grades, as well as to explore (3) students’ experiences when using an ARS system, and (4) their reasons for not answering ARS questions. With respect to the first research question, the study
### Table 3. Students’ ARS experience

<table>
<thead>
<tr>
<th>Categories</th>
<th>#</th>
<th>Comments*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>set-up</td>
<td>41</td>
<td>(too) short time-frame (14), course attendance (13), temporary limited (4), negative consequences in case of hindrance (2), should be used differently (1), nothing for universities (1), preference for homework (1), should be online (1), voluntary (1), anonymous (1), missing announcement (1), questions on different times (1)</td>
</tr>
<tr>
<td>ease of use, handling</td>
<td>22</td>
<td>Straightforward / uncomplicated (3), complex (2), cumbersome (2), complete questions should be displayed (2), bad internet connection (2), there are better solutions (2), well-arranged (1), unstructured (1), long loading time (1), slow Internet (1), bad for smartphones but good for tablets (1), intuitive (1), smooth submission (1), works (1), room for improvement (1)</td>
</tr>
<tr>
<td>technology</td>
<td>18</td>
<td>Internet / WLAN (5), smart phone (3), error message (3), technical problems (2), mobile (1), learning management system (1), online (1), laptop (1), iPad (1)</td>
</tr>
<tr>
<td>course time</td>
<td>8</td>
<td>early start (3), [no] time (2), too early in the morning (1), wake up (1), in class on time (1)</td>
</tr>
<tr>
<td><strong>ARS questions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>response behavior</td>
<td>74</td>
<td>speedy [decision] (22), teamwork (21), guessing [chance / luck] (9), searching (5), consulting slides / glossary (5), copy from a peer (2), prerequisite is theory, body of knowledge (2), preparation (2), precise reading (2), trustworthiness of peers (1), logical reasoning (1), lacking knowledge (1), effort (1)</td>
</tr>
<tr>
<td>levels of difficulty</td>
<td>44</td>
<td>simple (18), difficult (11), adequate (6), challenging (3), too difficult (2), sometimes difficult (2), logical (1), diverse levels (1)</td>
</tr>
<tr>
<td>content</td>
<td>18</td>
<td>application of knowledge (6), related to real life (5), good interesting questions (3), relates different subject areas (2), new questions (1), small section of course content (1)</td>
</tr>
<tr>
<td>clarity</td>
<td>11</td>
<td>well-thought-out questions (3), imprecise phrasing (3), ambiguity (2), plausible questions (2), puzzling answers (1)</td>
</tr>
<tr>
<td>design</td>
<td>9</td>
<td>supportive elements [videos, photos, diagrams] (4), single choice (3), multiple answers (1), simply designed (1)</td>
</tr>
<tr>
<td>general</td>
<td>5</td>
<td>questions (3), solutions (2)</td>
</tr>
<tr>
<td>number</td>
<td>5</td>
<td>many (2), not enough (2), five (1)</td>
</tr>
<tr>
<td>bonus credits</td>
<td>74</td>
<td>credits (57), not enough credits (9), low number of credits (5), bonus for participants (1), easily earned credits (1), means to an end (1)</td>
</tr>
<tr>
<td>grade</td>
<td>9</td>
<td>better grade (4), good grade (2), positive grade [70%] (2), entire credits (1)</td>
</tr>
<tr>
<td>learning</td>
<td>123</td>
<td>repetition (30), facilitates knowledge monitoring (22), training / practice (10), enhances learning, understanding (8), self-test (8), exam preparation (8), stimulates reading up / consulting a book (7), test (4), monitors / fosters learning process (3), solidify one's knowledge (3), stimulates students' reflection of their knowledge (3), summary (3), knowledge (3), broaden / extend one's knowledge (2), demonstration of knowledge (2), recall (2), provides feedback (1), identifying learning deficits (1), facilitates memorizing (1), provides an overview (1), wrap-up (1)</td>
</tr>
<tr>
<td>engagement</td>
<td>98</td>
<td>encourages participation (19), motivation to keep up (16), motivation (12), encourages / stimulates attention (10), motivation to follow the issue (9), discussion with peers (7), stimulates course attendance (6), forces course attendance (5), enhances concentration (4), comparison with peers (3), stimulates discussion (2), engagement with the topic (1), leads to involvement (1), stimulation (1), draws off the attention (1), poor stimulation (1)</td>
</tr>
<tr>
<td>positive</td>
<td>222</td>
<td>useful (43), interesting (30), nice change / break (16), good idea (11), enjoyable (10), funny (10), exciting (9), positive (9), beneficial (8), loosening up the course (8), entertaining (6), great (6), fair [assignment of credits] (6), informative (6), clever (6), satisfying (5), new (4), effective (3), spontaneous (3), innovative (2), rewarding (2), varied (2), knowledge-expanding (2), modern (2), unexpected (2), efficient (1), great, because only attendees can participate (1), joy at correct answers (1), important (1), recommendable (1), refreshing (1), surprising (1), unusual (1), curiosity (1), ambition (1), time saving (1)</td>
</tr>
<tr>
<td>negative</td>
<td>74</td>
<td>stress (16), useless (10), time pressure (9), time-consuming (6), confused (6), annoying (5), absurd (4), not beneficial (4), not interesting (2), unfair (2), uncertainty (1), anxiety (1), deviates from the lecture (1), boring (1), unacceptable (1), angry in case of wrong answer (1), discouraging (1), annoying because of time limit (1), disappointing (1), illogical (1)</td>
</tr>
</tbody>
</table>

### Table 4. Students’ causes for ARS non-participation

<table>
<thead>
<tr>
<th>Categories</th>
<th>#</th>
<th>Comments*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mismanagement</td>
<td>82</td>
<td>no knowledge / information (54), too late information / missed it (10), no access to questions (8), forgotten / overlooked (5), wrong information (1), not looked into that issue (1)</td>
</tr>
<tr>
<td>Non-attendance</td>
<td>68</td>
<td>no course attendance (63), no course enrollment (2), missed course enrollment (1), early start of the course (1), unfavorable time of the course (1)</td>
</tr>
<tr>
<td>Time constraints</td>
<td>33</td>
<td>no time (17), attendance of another [mandatory] course (9), at work (4), being abroad (1), writing thesis (1), studying for other courses (1)</td>
</tr>
<tr>
<td>Disutility factors</td>
<td>12</td>
<td>no interest (3), too little bonus credits (3), useless (2), time consuming (2), negative cost performance ratio (1), never used before (1)</td>
</tr>
<tr>
<td>External factors</td>
<td>10</td>
<td>short-term decision to write the exam (6), no mobile device (2), self-study (2)</td>
</tr>
<tr>
<td>Risks</td>
<td>2</td>
<td>anxiety (2)</td>
</tr>
</tbody>
</table>

*In brackets frequencies of mentions are given*
documents an improvement in students’ learning outcome when using an ARS. Therefore, it reinforces the branch of research that also identifies such an impact 
\[7, 49\]. However, it is still unclear whether the ARS integration into the course improves students’ retention and thus their grades. Another plausible explanation could be that course attendance motivated by the application of an ARS holds responsible for higher scores achieved in the exam. Thus, applying an ARS has either a direct or an indirect effect on students’ test performance.

The results relating to the second research question further strengthen the findings of the first research question. But let me discuss the research model developed to answer this research question (Figure 1) following the order of the hypotheses.

It has already been proven that systems which are believed to be useful enhance learning \[14\]. In the context of ARSs, this is supported by the present study. In accordance with previous literature \[26, 37\], it could further be shown that ARSs facilitate greater performance, i.e. that ARS question performance is better if the ARS is perceived more helpful. Since usefulness is important, this calls for the uncovering of the reasons for ARSs being perceived as useful or useless. Instructors may learn from students’ opinions, thereby eliminating obstacles or picking up arguments on the usefulness to later on persuade students of ARS usefulness. Another possibility is to have some testimonials who support usage (e.g. students who successfully used the ARS) videotaped. These videos could then be provided on the LMS for the benefit of all students.

Another impact factor mentioned in the literature is enjoyment. A common finding is that students enjoy ARS usage \[e.g. 18, 50\]. Matching the observation of earlier work \[25\], this study demonstrates that enjoyment is important to perceive an enhancement in learning. Contrary to expectations, however, no significant impact of perceived enjoyment on ARS question performance was found. This means that to some extent this study contradicts the findings of other scholars \[30\] who suggest that enjoyment enhances student’s learning success. This may be explained by the fact that students need to prepare for the course to get the answers right. Although students recognize that it would enhance their learning outcome, they do not seem to be willing to invest that much.

In general, self-efficacy suggests that students who are doubtful about their competences are easily discouraged and, as a consequence, struggle or fail, whereas more confident students succeed \[5\]. Self-efficacy is an indicator of success in several studies \[2, 8, 26, 45\]. However, it does not appear to be one in this research. A possible explanation for this might be that the lectures and/or the explanations of the ARS questions trigger students’ self-efficacy and confound the results of the study. Furthermore, the relationship between self-efficacy and ARS performance could also go in the opposite direction. This means that students’ self-efficacy increases when answering ARS questions correctly.

Coming back to the above-mentioned effect on students’ grades, this study’s findings confirm previous work \[10\] which suggests that the more questions are answered correctly the higher are students’ exam scores. This implies that students who work harder during the lecture and who are prepared to answer the ARS questions also benefit at the exam. Thus, ARS scores are identified as a predictor of exam performance. Since instructors have access to ARS scores, they can identify students who need additional support and may, for instance, provide them with specific assignments (e.g. through integration into the LMS). Of course, students themselves can also monitor whether they are “in danger” and adjust their study behavior accordingly.

As expected, the relationship between learning enhancement and grade is negative. Due to the overwhelmingly positive reports in previous studies, an overestimation of learning benefits was assumed. This negative relationship could also be caused by the answering behavior of students with responses towards one end of the scale (i.e. skewed distribution). Finally, it is possible that students believe in their learning enhancement, and therefore do not study enough before taking the exam.

One unanticipated finding is that anxiety does not impact students’ grades, as was proposed in the literature \[8\]. Perhaps the ARS experience put an end to students’ fears, either because students were able to solve the ARS questions, or because ARS question format is similar to the one of the exam questions, or because they simply understood all explanations.

The third research question deals with students’ experiences of using the ARS. In general, more positive than negative comments are given, thus corroborating the findings of other researchers \[27, 28\] who found evidence that students’ attitudes towards ARSs are positive. Nevertheless, this study contributes to the field because a systematic content analysis was conducted, whereas prior knowledge was based mainly on informal student feedback \[27\]. Besides all the benefits already mentioned by other researchers (see Chapter 1), a few more can now be added, such as solidifying one’s knowledge or wrapping-up course content (see Table 3). In addition, many emotional associations are brought up, amongst which especially the negative ones could be a valuable source of improvement. For instance, prolonging the time span to respond to a question could take off some time pressure and stress. Answers named
5.3. Conclusion

Using ARS allows a real-time reflection of students’ understanding. The study’s findings suggest that students’ ARS experience was predominantly positive. They find it useful, interesting, enjoyable and informative, and they see a variety of benefits in terms of improved learning and engagement (e.g. repetition, motivation to keep up, training, self-test, encouraged participation). For this reason, ARS usage makes it more likely that students retain some of the content taught. The fact that students who have participated in answering ARS questions obtained a better base of knowledge is confirmed by these students scoring higher in the exam. Furthermore, those students who achieved higher scores by answering ARS questions also outperformed others in the exam. Since this study reveals that neither self-efficacy nor anxiety interfere with the overall grade, it is the students’ revision that matters. Posing ARS questions are a means to encourage students to start early with their preparation to enable them not only to answer ARS questions correctly, but also to do well in the exam.

In sum, the ARS was found to be a pedagogically valuable tool to enhance students’ learning success. The findings presented in this paper strongly support further ARS application.

References


