Audience Response System - an Inclusion of Blended Mentoring Technology in Computer Engineering Education

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***Abstract*—This Research-to-Practice Work-In-Progress paper explores the subjective evaluation of an Audience Response System (ARS) as a blended mentoring technology included in the pedagogical approach in computer engineering education. The ability to use scientific research methodologies represents a crucial competence for students in the field of computer engineering. In addition, this covers a wide range of sub competencies required for their future work according to the competency model of information technology (IT) industry. Imparting these competences is ensured by a seminar representing the testbed for this exploratory study. The study objective is to analyze the subjective evaluation of the ARS technology as blended mentoring method. Therefore, the ARS is used to created opportunities for the lecturer and the students to initiate discussions focused on the learning objectives in the seminar. The research approach bases on a qualitative exploration and set it into relation of final grade and ARS usage frequency. The qualitative results show the acceptance of the ARS technology by the students and indicate a suitable approach in education. In addition, positive feedback is received for the bidirectional discussions, confirming the expectation by the theory of Zone of Proximal Development. Furthermore, the grading analysis indicate a positive influence of the ARS on the final grade depending on usage frequency.**

***Index Terms*—E-learning tools, Personalized E-learning, Devices for learning**

I. Introduction

Thousands of academic and institutional programs around the world include mentoring as a strategy to foster and facilitate academic progress and career advancement [1]. Current research results demonstrate the effectiveness of mentoring in science, technology, engineering, and mathematics (STEM) [2] and in certain application-oriented disciplines of computer engineering education [3], [4]. In the reciprocal process of mentoring, the mentor uses instruction characterized by a rich understanding of the cognitive process and is led by the mentee's individual needs and interests [5].

With the evolution of E-learning and Web 3.0 technology, a computer mediated online communication based variation of traditional mentoring has been expanded to E-mentoring and blended mentoring [6]. Blended mentoring refers to have more than one means of communication in the mentoring process including face-to-face mentoring sessions accompanied by communication or mediation through e-learning tools [7]. Previously (in 2009-2011) [7], blended mentoring used the benefit of email and social media to initiate discussion between mentor and mentee in order to provide consultation in both virtual and real time presence. The development of various user-friendly technologies used as e-learning tools led to the possibility to practice and apply the theoretical knowledge [7].

E-learning tool usage helps the lecturer to take the mentor's role of training and consulting the computer engineering students within the context of complex real world tasks [4]. Amidst the e-learning tools, audience response systems (ARS) have gained the popularity to improve engagement and interaction in a large group of students in higher education [8], [9]. The system function bases on the combination of the three processes: Presentation of the questions, reception of the audience's answers via hand-held devices and display of the aggregated results [9].

Due to the relevant features for receiving direct responses from the audience and the possibility of providing live feedback [10], ARS offers a solid basis for implementing blended mentoring in a lecture [11] . However, the usage of ARS only is not sufficient to be considered as mentoring, since a major characteristic of mentoring is represented by the personal interaction and consideration of the mentees need [5]. This study analyses the usage of ARS as blended mentoring tool if it is used to force questions regarding common mistakes. Therefore, the basic idea is to use difficult real world questions that reflect the learned content to force frequent mistakes. Students are guided through these mistakes resolving the misconceptions in a subsequent discussion.

In the following sections, the theoretical framework is described followed by the methods used describing the testbed, the ARS design and the qualitative evaluation methods. Afterwards the results are reported and discussed, finally the future work is illustrated.

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II. Theoretical Framework

The bidirectional process of mentoring aims at providing guidance to the less experienced individual i.e. students by the more experienced individual i.e. the mentor or lecturer [5]. Decades of research provides the theoretical roots of mentoring on adult learning and higher education [12].

Given the e-learning technology context, e-mentoring has evolved and prove its effectiveness to enhance academic performance [13]. E-mentoring has an added advantage of scaling the traditional mentoring up to provide support of increased interaction within a large group of students [13]. In line with this feature of e-mentoring, blended mentoring refers to the implementation of information technology (IT) into the traditional setting of mentoring where students are able to benefit from the technologies of e-mentoring while also receiving direct and personal advice from the traditional method [7].

The pedagogical approach of ARS in particular offer the functions of providing tasks or objective type questions, allowing anonymous answers utilizing e-learning tools and incorporating face-to-face feedback discussion session [14]. The first manual usage of ARS in lectures of higher education was reported 49 years ago [10]. The development of mobile and educational technologies evolved the ARS to a response platform along with mobile devices as response media included in learning management systems and online assessment systems [15]. Several empirical studies [9], [15], [16] have similarly demonstrated the value of encouraging student engagement in lectures through computer-integrated response system. Therefore, the scaffolding technique of giving task and guidance afterwards is embedded in the teaching learning process of ARS [17]. The idea of scaffolding was developed from the concept Zone of Proximal Development (ZPD) by Lev Vygotsky [18]. ZPD is given as a zone or distance between the actual development and the potential development of the learners [19]. Under expert guidance, learners' development can be increased to the level of potential development at which they become independent learners [20]. The development in the ZPD occurs through scaffolding which are instructional supportive activities and interaction among the learners, instructors and learning materials [20]. The scaffolding technique includes competence modeling, initializing and maintaining interest and motivation [18]. With the aid of appropriate scaffolding strategy, the learner can gain knowledge and skill by practicing and completing tasks with the assistance of the mentor [21]. This happens in the ZPD zone till the learner takes the ownership of his own learning and complete the task independently which is the level of learner's potential development [20]. This concept of ZPD has emerged in discussions of modern pedagogical practices like the use of formative assessment as a teaching-learning tool [22].

The common thread between the formative assessment practices and the learning through mentoring practices is the idea of providing challenging but reasonable tasks that stimulate learner's thinking. The task oriented feedback interaction and discussion helps to create a learning environment where the learners realize that their thought processes are being acknowledged and accepted [10]. The evolution of e-learning tools in 21st century have paved the way of ARS being used as formative assessment tool in every kind of teaching learning scenario including mentoring [23]. Taking in consideration of these theories, this study explores the enabling feature of ARS technology as blended mentoring tool and the computer engineering student's notion of acceptance towards the inclusion of ARS.

III. Methods

A. Testbed

A seminar for learning scientific working methods is provided as testbed for ARS acceptance evaluation as blended mentoring tool. The course is divided into a lecture part to impart the theoretical background and a practical exercise part. The lectures are used to explain methods necessary for fulfilling high scientific standards in the field of literature survey, presentation style and preparation, professional discussion just as scientific writing and reporting representing the evaluation criteria. The examination is done by presenting the state of the art of a self-chosen topic and writing a scientific report of 10 to 15 pages of content. The learning outcomes of the course cover a wide range of competences required in the field of computer engineering following the competency model of information technology (IT) industry [24]. The course trains competencies from the tiers – Personal Effectiveness Competencies, Academics Competencies, Workplace Competencies and Industry-Wide technical Competencies, by self determined work on real world industry topics, by using scientific methods for elaborating the presentation followed by a series of questions and a report.

In the semester of the evaluation process 62 students were registered in the course. There of 52 students gave a presentation with following questioning whereof 47 students submitted a report until the given deadline, leading to an overall dropout rate of 24% mainly reasoned by disease-related absences for the presentation attested by medical certificates.

B. ARS Test Design

Imparting the scaffolding technique in the lecture session following the ZPD concept is realized with a total amount of four ARS tests, one for each main field of study. The design of the respective ARS tests focuses on the reflection of the learning outcome understanding by applying it to real world scenarios inspired by frequent mistakes from previous semesters. These represents the application level of the cognitive domain of Bloom's Taxonomy providing a basis for discussing of frequent mistakes and providing a mentoring opportunity. During the discussion the lecturer, taking the role of the mentor, can guide the students to a correct understanding by pointing out the mistakes made.

In this context, the ARS test for literature survey analyses the understanding of the trustworthiness of literature sources and the classification of the trustworthiness of four publications on the basis of the title page, the number of citations depending on the year of publication and the APA formatted reference. The second ARS test compares two videos of one minute length. The first video shows a business presentation and the second the presentation of a scientific conference. The students are asked to indicate which parts of the body language, pronunciation and the use of the presentation media are appropriate for a scientific presentation. The ARS test on the topic of discussion provides a selection of student answers from previous semesters to frequently asked questions, whereby their suitability for scientific argumentation has to be assessed. The last ARS test for scientific writing addresses the topics plagiarism and citation. For this reason, direct and indirect citation examples are provided, which have to be checked for correctness by the students regarding formal criteria and context. Each of the ARS tests was conducted by 26 to 29 students leading to a participation rate of approximately 50% to 56% of the students giving the presentation.

C. Qualitative data collection and analysis

The qualitative data collection of this study was completed by conducting 18 semi-structured individual interview and one semi-structured paired depth interview [25] to obtain the point of saturation. Each of the 19 interviews lasted for maximum nine minutes and was audio recorded by the consent of the interviewees. Criterion sampling was done among voluntary participants. The interviewees demographics comprise of 70% from India and rest are from Bangladesh, Germany, Nigeria and Pakistan. The criteria was set to identify the sample who responded in ARS. The same semi-structured interview protocol has been used in both kind of interviews. The interview design contains a preset of four themes to be explored during the data collection. These themes are the familiarity and preferences of e-learning, Acceptance of ARS in teaching-learning activities, Content wise effectiveness of ARS and Attitude towards learning with ARS.

In this study, the qualitative data analysis software package MAXQDA Analytics Pro 2020 is used to conduct both the intelligent verbatim transcription and thematic analysis using a combination of deductive and inductive coding. The deductive coding framework is a subset of the preset themes from the semi-structured interview. After studying the dataset the inductive coding framework has been developed which were missing in the deductive codes. 174 coded segments of the interview dataset forms a total of 28 categories. These categories then organized in the four corresponding themes with an additional emerging theme in order to obtain the thematic saturation.

IV. Results

A. Link between familiarity with e-learning and preference of learning setting

About 40% of Interviewees think that e-learning is to do online literature search, maintaining communication between peers and conducting collaborative group work via online medium. On the contrary, 20% interviewees stated that e-learning is attending online courses with or without the provision of achieving certificate, studying in online library, participating in different courses provided by the online learning management systems. They opined it as a scope of developing their skills while being engaged in self-regulated learning. While talking about their preference of learning settings, 25% interviewee expressed their preference towards e-learning whereas, 20% have shown to prefer face-to-face learning and 5% have reported disliking towards e-learning.

B. Acceptance of ARS as a learning technology

This theme has been constituted with the deduction of 8 categories. These are: 1. Supporting feature in course, 2. Most liked feature in course, 3. Disliked feature of ARS, 4. Concern about ARS, 5. Recommendation to improve, 6. Future usage in other courses, 7. Affirmation to use in other courses and 8. Discussion with peers. These infer a notion of acceptance of ARS among the interviewees. Responses show that 35% of the interviewees recognize ARS as a supportive feature of the course keeping them motivated to focus more in the lecture, improves their metacognition ability along with the immediate scope of clarifying their understanding about a particular topic. About 45% of them have indicated ARS as their most liked feature in the course. Because they get the immediate feedback of the tasks of the ARS along with the explanation of the feedback and it circulates a positive emotion and increased motivation within themselves. They could be aware of their own knowledge level as stated in the following quote:

> "I like the ARS part where it creates the awareness like how much I understood about the course."

The theme is highlighted while 90% of the interviewees have expressed their affirmation to use this kind of ARS in future in other courses to have interactive classes. Furthermore, their discussion with peers about ARS and stating the recommendations and expressing their concern about ARS show their approval to use it as a learning technology.

C. Content-wise effectiveness of ARS

The described learning scenario has been reported from 85% of the participants as a first-hand experience using such type of learning technology. The content of ARS has helped 20% of the interviewee to build their self-concept of learning by providing them the opportunity of metacognitive support and self-evaluation. Interactive feedback discussion session, multimedia content and the scope of revision of the lecture in ARS are reported by all 20 interviewees to guide in achieving the competencies of scientific research and presentation.

D. Attitude towards learning with ARS

Among the interviewees 70% have reported their experience of the ARS session with positive emotional state. The learning experience is unique to all 20 interviewees because of the implementation of live online test of ARS. Additionally, 35% indicated that critically thinking was initiated while acknowledging other's opinion and 60% have stated it as

TABLE I
AVERAGE GRADING RESULTS FOR PRESENTATION, REPORT AND FINAL GRADING DEPENDING ON SUBGROUPS.

Category	ARS_{WC}	ARS_{none}	ARS_{M1}	ARS_{all}
Presentation	75.98%	73.16%	77.39%	77.57%
Report	78.96%	75.06%	81.24%	82.13%
Final Grading	76.09%	72.74%	78.05%	81.00%

a measurement of their understanding. While 85% of the interviewees have reported an increase in interaction with their peers and lecturer due to the ARS, they think that it makes this lecture different from the traditional lecture. Two among 20 interviewees have explicitly considered themselves as active learners whereas 80% have reported that the mistakes that they made, have motivated them to learn the content.

E. ARS as self-test: Scope of independent learning

This is the emerging theme with 90% of the interviewees' (n=18) opinion on behalf of using the questions of ARS as self-test which they would be able to solve themselves individually at home. As they can get the instant feedback from the online self-test, they perceive it as a helpful feature of the online course in order to get continuous practice session at home. They stated that the ARS as self-test would help the students who missed the lecture as well as rendering the provision to revise the content. The self-test is recognized as an option of self-reflection by 20% of them, pointing out drawbacks while having the flexibility of time in their own learning spaces.

F. Grading Results

In addition to the qualitative results, the influence of the ARS tests on grading is analyzed accordingly. Therefore four different subgroups of students are distinguished representing ARS usage frequency: whole course (ARS_{WC}), students participated at least one ARS test (ARS_{M1}), students participated at all ARS tests (ARS_{all}) and students haven't participated at any ARS test (ARS_{none}). Note that ARS_{M1} and ARS_{none} are disjoint but ARS_{all} is a subset of ARS_{M1} leading to a group size of 17 students for ARS_{none}, 34 students for ARS_{M1} and 19 students for ARS_{all}.

The grading was analyzed for the given scientific presentation including the discussion and the written report just as the final grading. The average grading for these categories is visualized in Table I. The table shows a lower average score for ARS_{none} compared to the overall course average and ARS_{M1} in the overall final grading as well as for the partial scores. Furthermore, it can be seen that ARS_{all} achieves the best results in all categories. In particular, the difference between the disjoint groups ARS_{all} and ARS_{none} in the final grading of 8.26% should be noted, as this corresponds to a grading difference of almost two grading steps. Another observation is that the average scores of the subgroup ARS_{all} are higher than ARS_{M1} in all categories, especially in the final grading with a difference of approximately 3% compared to the slightly higher scores in the subcategories with approximately 0.2% and 0.9%.

V. DISCUSSION AND CONCLUSION

The results of the present study are explored via subjective evaluation of ARS as blended mentoring tool in the particular context of higher education in computer engineering. The analysis of qualitative interview data and quantitative data curated from the testbed showcase towards the acceptance of ARS in terms of application, effectiveness and learner-support.

The qualitative analysis shows that 90% of the interviewees report the wish of further usage of ARS in other lectures. Additionally, 35% report ARS as supportive while 45% call it the most liked feature in the course. On the other hand, the interview shows that only 20% have an in-depth understanding of e-learning and that 25% of the interviewees prefer a face-to-face setting or dislike e-learning. In summary, this shows a broad acceptance towards the inclusion of ARS in the university lectures. Despite of being the first hand experience of most of the interviewees, all of them realize ARS as an overall guidance to prepare their scientific presentation and report. Their statements highlighting the opportunity of iteration, metacognition and self evaluation of the interrelated learning processes with the use of ARS. This facilitates sustainable learning, as one of the interviewee explicitly states:

> "[...] because I think ARS is the best way to learn something new or correct ourselves and remember something for the long term."

The results also show that the ARS content helps the interviewees to build their self-concept of learning, to reflect the understanding of the context critically and increases the perception as active learners. The combination of both e-learning and traditional learning setting of ARS helps the student in clarifying their misconception, confusion and in receiving replies of their queries through interactive discussion with the lecturer. As one of them said:

> "After the test session, we had this answer discussion where our professor used to tell us this is what we supposed to do. That was [...] an eye-opener for me."

The qualitative findings show that the scaffolding [22] of ARS provides the students to get the opportunity of training with a combination of consultation afterwards [10]. This reflects the mentoring provision of the learning technology [7]. This is supported by the quantitative analysis of the course results, since the students using ARS scores above the course average in all sub-scores just as in the final grading, while the students without ARS usage score below the course average.

In conclusion the results represent that the ARS can be considered as blended mentoring tool as long it is used to initiate discussions about frequent mistakes to guide the students to solve their misconceptions. As the results mostly based on the semi-structured interview in one course only, an extensive quantitative evaluation in a larger sample is required to generalize the results. Following the results, a follow-up study on the introduction of ARS as a self-test is recommended. Moreover, further studies should be conducted to investigate the psycho-social support of ARS as blended mentoring technology.

References

[1] J. E. Girves, Y. Zepeda, and J. K. Gwathmey, "Mentoring in a post-affirmative action world," *Journal of Social Issues*, vol. 61, no. 3, pp. 449–479, 2005.

[2] H. Stoeger, X. Duan, S. Schirner, T. Greindl, and A. Ziegler, "The effectiveness of a one-year online mentoring program for girls in stem," *Computers & Education*, vol. 69, pp. 408–418, 2013.

[3] J. McCarthy, "International design collaboration and mentoring for tertiary students through facebook," *Australasian Journal of Educational Technology*, vol. 28, no. 5, 2012.

[4] E. H. Trainer, A. Kalyanasundaram, and J. D. Herbsleb, "E-mentoring for software engineering: a socio-technical perspective," in *2017 IEEE/ACM 39th International Conference on Software Engineering: Software Engineering Education and Training Track (ICSE-SEET)*. IEEE, 2017, pp. 107–116.

[5] A. Ziegler, "Mentoring: Conceptual basics and effectiveness analysis," *Mentoring: Theoretical Background, Empirical Findings and Practical Applications*, pp. 7–29, 2009.

[6] W. M. Murphy, "From e-mentoring to blended mentoring: Increasing students' developmental initiation and mentors' satisfaction," *Academy of Management Learning & Education*, vol. 10, no. 4, pp. 606–622, 2011.

[7] E. Argente-Linares, M. C. Pérez-López, and C. Ordóñez-Solana, "Practical experience of blended mentoring in higher education," *Mentoring & Tutoring: Partnership in Learning*, vol. 24, no. 5, pp. 399–414, 2016.

[8] G. Heaslip, P. Donovan, and J. G. Cullen, "Student response systems and learner engagement in large classes," *Active Learning in Higher Education*, vol. 15, no. 1, pp. 11–24, 2014.

[9] J. Cain and E. Robinson, "A primer on audience response systems: current applications and future considerations," *American journal of pharmaceutical education*, vol. 72, no. 4, 2008.

[10] N. J. Hunsu, O. Adesope, and D. J. Bayly, "A meta-analysis of the effects of audience response systems (clicker-based technologies) on cognition and affect," *Computers & Education*, vol. 94, pp. 102–119, 2016.

[11] T. L. Wendling, *Transitioning novice nurse practitioners into practice through a blended mentoring program*. Northern Kentucky University, 2016.

[12] S. Kumar, C. Wallace, and M. Young, "Mentoring trajectories in an evolving agile workplace," in *2016 IEEE/ACM 38th International Conference on Software Engineering Companion (ICSE-C)*. IEEE, 2016, pp. 142–151.

[13] K. N. Rowland, "E-mentoring: An innovative twist to traditional mentoring," *Journal of technology management & innovation*, vol. 7, no. 1, pp. 228–237, 2012.

[14] S. Burgess, S. Bingley, and D. Banks, "Blending audience response systems into an information systems professional course," *Issues in Informing Science and Information Technology*, vol. 13, pp. 245–267, 2016.

[15] S. McClean and W. Crowe, "Making room for interactivity: using the cloud-based audience response system nearpod to enhance engagement in lectures," *FEMS microbiology letters*, vol. 364, no. 6, 2017.

[16] R. Salzer, "Smartphones as audience response systems for lectures and seminars," *Analytical and bioanalytical chemistry*, vol. 410, no. 6, pp. 1609–1613, 2018.

[17] S. E. Silliman, K. Abbott, G. Clark, and L. McWilliams, "Observations on benefits/limitations of an audience response system," *age*, vol. 10, p. 1, 2004.

[18] I. Thompson, "The mediation of learning in the zone of proximal development through a co-constructed writing activity," *Research in the Teaching of English*, pp. 247–276, 2013.

[19] L. S. Vygotsky, "The development of scientific concepts in childhood," *The collected works of LS Vygotsky*, vol. 1, pp. 167–241, 1987.

[20] S. Chaiklin *et al.*, "The zone of proximal development in vygotsky's analysis of learning and instruction," *Vygotsky's educational theory in cultural context*, vol. 1, pp. 39–64, 2003.

[21] K. Jaxon, "11 creating a connected space: Mentoring in the zone of proximal development," *Teaching writing in high school and college: conversations and collaborations*, p. 169, 2002.

[22] D. Ash and K. Levitt, "Working within the zone of proximal development: Formative assessment as professional development," *Journal of Science Teacher Education*, vol. 14, no. 1, pp. 23–48, 2003.

[23] M. L. Shirley and K. E. Irving, "Connected classroom technology facilitates multiple components of formative assessment practice," *Journal of Science Education and Technology*, vol. 24, no. 1, pp. 56–68, 2015.

[24] Employment and Training Administration United States Department of Labor, "Information technology competency model," September 2012. [Online]. Available: www.careeronestop.org/competencymodel/info_documents/it-industry.pdf

[25] A. D. Wilson, A. J. Onwuegbuzie, and L. P. Manning, "Using paired depth interviews to collect qualitative data," *The Qualitative Report*, vol. 21, no. 9, p. 1549, 2016.