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Improving the efficiency of remote conference tool use for distance learning in higher education: A kano based approach

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ABSTRACT

During the COVID-19 pandemic, higher education institutions around the world were challenged to shift from traditional to distance teaching processes. This was not an easy task as educational institutions had to face many technology and human related challenges. The purpose of this paper is to present an approach that helps teachers to use remote conference tools (RCT) for a particular course more efficiently. The approach enables both teachers and students to be more effective in online education in general and during pandemics. The proposed approach leans on the Kano model and specifically focuses on evaluation of RCT features (RCTF) from students’ and teachers’ perspectives. Such evaluation enables development of recommendations for effective RCTF use. The approach was tested in three different case studies: Case 1 (computer and information science – software development; 39 students, 2 teachers), Case 2 (criminal justice and security – introduction to information systems; 130 students, 2 teachers), Case 3 (applied kinesiology – statistics; 44 students, 2 teachers). In all three cases, the results clearly demonstrated the benefits of the proposed approach and showed that the use of RCTF should be adapted to the specifics of each course where lectures and tutorials need to be considered separately.

1. Introduction

The COVID-19 pandemic has forced people to introduce many changes in all areas of life. These include education where schools on all levels including higher education switched to distance teaching in most countries in the world (Martin et al., 2020; UNESCO, 2020). One of the biggest challenges in higher education was the requirement to switch from physical to virtual lectures and tutorials (Turnbull et al., 2021). Regardless of the fact that the education sector must be well prepared for crisis situations (Bergdahl & Nouri, 2020) there was not enough time to systematically prepare for distance learning (Lohr et al., 2021). Although higher education institutions relatively quickly adapted and offered technological solutions for distance learning to teachers and students, these were not equally suitable to the needs of all courses (Turnbull et al., 2021). Also, detailed decisions on how to use these technologies in practice were typically left to the teachers who had little or no experience with them (Kyrkjebø, 2020; Turnbull et al., 2021). Among the key technologies for distance learning proved to be remote conference tools (RCT), such as Zoom, BigBlueButton, Skype, Microsoft Teams, WebEx, etc. (Chick et al., 2020). This paper focuses on the use of RCT and several related challenges that surfaced during the pandemic. First, there are many providers of RCT, and each RCT has different features and capabilities. Second, RCT offer different sets of features

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which do not always meet the requirements of a particular course consequently forcing users to use more than one RCT thereby reducing the user experience and productivity (Fischer et al., 2020; Karr-Wisniewski & Ying, 2010; Zanjani et al., 2017). Moreover, learning outcomes may become dependent on available RCT features and capabilities (Kyrkjebø, 2020). Third, not all teachers and students are equally skilled at using RCT and their varying features (Bryson & Andres, 2020). Therefore, an important issue is to identify RCT features (RCTF) that have the most beneficial effect on the efficiency of distance learning for a particular course. Identification of such RCTF enables us to select the most appropriate RCT and use it more efficiently.

Generally, the question of the defining software features is addressed by requirements engineering (Kasauli et al., 2021). In this context, RCT can be considered as any other software having different features. Requirements engineering provides processes and techniques that help define features that address the needs of software users (Schön et al., 2017). These needs may change over time due to various factors (e.g., legislation change, changing user needs, market changes, significant events, such as pandemics, etc.) (Shafiq et al., 2018). Due to the COVID-19 pandemic, many lecturers were faced with the requirement to provide their courses online (Tang et al., 2021; Y. Zhao et al., 2021). Even though some of them might have been using RCT before, most of them have never used RCT to provide courses online. On one hand, this forced them to acquire new RCT skills (Moorhouse & Kohnke, 2021). On the other hand, it exposed the weaknesses of existing RCT. Many of the exposed weaknesses were eventually addressed by RCT providers who introduced improvements and new features to RCT aimed at supporting the needs of lecturers. However, lecturers were mostly left without more specific guidance on which RCTF to use in their own courses. In our paper, we propose a model that helps teachers identify the RCTF that are the most beneficial in their particular courses. To do this, we lean on the Kano method (Kano et al., 1984) that has been used in the context of requirements engineering (Nayebi & Ruhe, 2019; Xu et al., 2019). The Kano method enables the identification of RCTF that deliver the highest benefits for distance learning and assign these features to different quality categories. While various evaluation approaches have been proposed to evaluate RCT use in education during COVID-19 pandemic (Al-Taweel et al., 2021; Kuleva, 2020; Pal & Vanija, 2020; Zamora-Antunano et al., 2021) none of those approaches evaluates RCT by its features which is crucial to be able to adapt RCT use to the needs of the course (Kyrkjebø, 2020). Additionally, as each stakeholders group interacts differently with the system (Aparicio et al., 2016), it is important to consider their different needs and interests. However, the above-mentioned evaluation approaches consider either only students’ or only teachers’ opinions while neglecting different interests of these two groups. To overcome these two issues we lean on our existing approach for evaluation of pedagogical process in higher education (Hovelja, Vavpotič, & Zvanut, 2016; Vavpotič, Zvanut, & Trobec, 2013). This approach facilitates evaluation of pedagogical process by its elements and concurrently considers key stakeholders (students’ and teachers’) opinions. Leaning on the above-mentioned evaluation approaches, our existing approach and Kano method we propose a novel approach for evaluation of RCT at the level of its functionalities (RCTF) in the context of higher education that considers opinions of different stakeholders. The development of the approach was guided by the following four research questions:

- RQ1: How can we evaluate the efficiency of use of RCT at the level of its functionalities (RCTF) in specific university courses that are provided online?
- RQ2: How can we concurrently consider teachers’ and students’ opinions in such an evaluation?
- RQ3: Can such an evaluation be used to identify less effective/ineffective RCTF in a specific university course?
- RQ4: Can results of such an evaluation be used to create concrete recommendations for the use of RCTF that would help teachers use RCT more effectively?

The aim of our study was to develop an approach that would help teachers to use RCT more efficiently for a particular course. This would allow teachers and students to be more effective in online education during pandemics. To the best of our knowledge, no similar approach is currently available in the literature.

The remainder of this paper is structured as follows. Following this introduction, we present a review of the literature in the field of the Kano method and its application in the field of requirements engineering in Section 2. Section 3 proposes Kano-based evaluation of remote conference tools features in higher education. In section 4, we present case studies from three different universities. Finally, we offer theoretical and practical implications, limitations, and future directions.

2. Literature review

After a review of the relevant literature, we can conclude that there is not much research devoted to RCT technologies. This is also noted by Martin et al. (2020) in their systematic literature review of research on online teaching and learning between 2009 and 2018 in which they state that course technologies are one of the less frequently studied research themes (Martin et al., 2020).

In 1968, Engelbart and English from the Stanford Research Institute (Engelbart & English, 1968) presented a prototype of a real-time videoconferencing tool. With this invention they set a new milestone in history and outlined new directions for the future of videoconferencing systems. Later, more and more researchers devoted themselves to the study of online conferencing systems (Crowley et al., 1990; Ohmori et al., 1992). The overall development of the technology and globalization additionally contributed further to the development of videoconferencing tools (Andrews & Klease, 1998). Authors use different terms for similar paradigms. For instance, terms, such as a collaboration tool (Hurst, 2020), a web conferencing tool (Gegenfurtner et al., 2020; Hurst, 2020), webinar technology (Toquero & Talidong, 2020), videoconferencing technology (Parikh et al., 2019), and teleconferencing (Chick et al., 2020), are all significantly overlapping with RCT. Similarly, the terms tool, platform, and software are used interchangeably.

Different RCT provide different functionalities and consequently a different user experience. In software development, expected functionalities are defined during the requirements engineering process (Beimel & Kedmi-Shahar, 2019; Ramesh et al., 2010). To
determine the value of different software requirements (i.e. expected software functionalities), the Kano method was used in the past (Alsawalqah et al., 2013; Kern & Refflinghaus, 2018; Mustasfa, 2014). The Kano model (see Fig. 1) was introduced by Kano et al. (1984), and is a popular method for assessing requirements, functionalities of physical products, etc. (Xu et al., 2019). This is important because the success or failure of a software implementation can occur due to an incorrect decision on the implementation or non-implementation of specific functionalities (Nayebi & Ruhe, 2019).

The Kano model facilitates classification of software requirements into several quality categories according to customers’ needs (Zdravkovic et al., 2015). Fig. 1 shows different Kano categories where y-axis measures the level of satisfaction and x-axis measures the level of requirement implementation. The original Kano model differentiates between four main types of quality categories: must-be (M), one-dimensional (O), attractive (A), and indifferent (I) (Nayebi & Ruhe, 2019; Vavpotič, Robnik-Sikonja, & Hovelja, 2020; Xu et al., 2019; S.; Zhao et al., 2020). The requirements that users expect software to have are classified as must-be. If such requirements are not adequately implemented (low implementation level), it leads to significant dissatisfaction of users. However, raising the level of implementation beyond a certain threshold does not contribute to the satisfaction of users. Requirements for which higher level of implementation also means greater user satisfaction are classified as one-dimensional. For this quality category, the relation between functionality and satisfaction is linear. Requirements that increase user satisfaction when implemented but do not decrease satisfaction when not implemented are classified as attractive. Requirements that do not show any significant relationship between user satisfaction and the implementation level are classified as indifferent. Berger et al. (1993) extended the original Kano model by adding reversed Kano quality categories: (A') reversed attractive, (M') reversed must be and (R') reversed one-dimensional. Reversed quality categories cause user satisfaction when implementation level of a requirement is low and/or dissatisfaction when high. In practice, this means that users prefer that such feature is not implemented. Some authors consider a final quality category, namely questionable (Berger et al., 1993; Nayebi & Ruhe, 2019; S.; Zhao et al., 2020). Questionable implies that there is a contradiction in the customer’s answers to the questions (Berger et al., 1993). Finally, an important element in the Kano diagram is also time, because over some time attractive quality category of some feature eventually becomes must-be. Kano (2001) point out the example that the television remote control was first an attractive quality category then over time it fell into one-dimensional quality, and at the end it was a must-be quality category.

In addition to the Kano model, other forms of evaluation of distance learning tools can also be found in the literature. For example, Zervos et al. (2013) examine students’ and teachers’ favorite functionalities of online classrooms. The study focuses on the Moodle platform, and not on a specific RCT. Similarly, Walek et al. (2018) address massive open online courses from the perspective of user roles while examining more specific functionalities, such as video, audio, communication, etc. Ismaili (2021) investigate the attitudes towards distance learning during the COVID-19 pandemic using a questionnaire to measure students’ satisfaction in general. In addition to these studies, evaluation methods using a qualitative approach (e.g., interviews, open-ended questions) can be found in the literature. For example, Correia et al. (2020) conducted an analytical evaluation of RCTF and focus on more specific functionalities, such as screen sharing, file transfer, breakout rooms, chat, etc. Ismail et al. (2021, pp. 1565–1570) use interviews to determine the shortcomings of RCT, specifically, Zoom and Microsoft Teams. Abushamleh and Jusoh (2021) also focus on Zoom and Microsoft Teams, and use a questionnaire to examine users’ satisfaction based on whether the system is well integrated, whether it has all the desired functionalities, etc. Isobe and Ito (2021) focus on security requirements of RCT by analyzing their cryptographic protocols. However, none of the existing studies evaluates key stakeholders’ satisfaction with specific RCTF with the aim to provide RCT improvement recommendations. In our paper we propose an approach that addresses this shortcoming.

3. Proposed evaluation approach

In this section, we present our proposed approach for evaluation of RCTF. Fig. 2 presents the four key activities of the proposed approach.

The first activity focuses on identifying the RCTF that should be evaluated. Identification is performed by a focus group comprising

Fig. 1. Kano’s diagram adapted from (Berger et al., 1993) which is considered as the basis for the requirements engineering in our model. Notes: Must-be (M), Reverse must-be (M'), One-dimensional (O), Reverse one-dimensional (O'), Attractive (A), Reverse attractive (A').

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students and teachers who discuss how different RCTF affect the course pedagogical activities. The key artefact that is created in this activity is a list of RCTF that are evaluated in further activities by both students and teachers. Additionally, teachers determine each RCTF status as either in use, not in use but implemented or not implemented. We define teachers as both lecturers (those who carry out lectures) and assistants (those who carry out tutorials).

In the second activity, questionnaires to evaluate RCTF identified in the first activity are developed. The questionnaires are based on the extended Kano model (Berger et al., 1993) which considers eight basic categories (A, M, O, I, A’, M’, O’ and Q) as described in the literature review section. Evaluation of each specific RCTF \( e \) is based on a functional \( e_f \) and a dysfunctional \( e_d \) part. For the functional part, the question “How do you feel if the feature \( e \) is present?” is used, and for the dysfunctional part the question “How do you feel if feature \( e \) is not present?” is used. For both parts, respondents provide their answers on the same scale: 1 (I like it that way), 2 (It must be that way), 3 (I am neutral), 4 (I can live with it that way) and 5 (I dislike it that way). The survey questionnaire must include detailed RCTF descriptions to ensure a common understanding of all RCTF (including those that have not been implemented or are not in use) among respondents. The survey is conducted separately among students and teachers. Each specific feature \( e \) is evaluated only by students and teachers who participate in a certain course.

In the third activity, survey results are analyzed in order to identify RCTF with the highest potential for improvement based on concurrent consideration of students’ and teachers’ net satisfactions. Evaluation of a specific feature \( e \) by a respondent is categorized into one of the eight quality categories according to the extended Kano model (Berger et al., 1993), and thus assigned to one of the following sets accordingly (\( M_e \) – mandatory, \( A_e \) – attractive, \( A_e' \) – reverse attractive, \( O_e' \) – reverse one dimensional, \( M_e' \) – reverse mandatory, \( O_e \) – one dimensional, \( I_e \) – indifferent, \( Q_e \) – questionable):

\[
M_e = \{ e | e_d = 5 \land (e_f = 2 \lor e_f = 3 \lor e_f = 4) \}
\]

\[
A_e = \{ e | e_d = 1 \land (e_f = 2 \lor e_f = 3 \lor e_f = 4) \}
\]

\[
O_e = \{ e | e_d = 1 \land e_d = 5 \}
\]

\[
A_e' = \{ e | (e_f = 2 \lor e_f = 3 \lor e_f = 4) \land e_d = 1 \}
\]
evaluate RCTF as reverse Kano quality categories. In the following formulas, 
Fig. 3. Scatterplot representing an illustrative example of RCTF positioning based on their net thresholds range from 1 to 1 where positive values of indicate that users are satisfied if feature is implemented while negative values of indicate that users are dissatisfied if feature is implemented. Similarly, the thresholds range from 1 to 1 where positive values of indicate that users are dissatisfied if feature is not implemented while negative values of indicate that users are satisfied if RCTF is not implemented. Finally, we calculate the net satisfaction thresholds range from 2 to 2 where negative values indicate net dissatisfaction and positive values indicate net satisfaction with RCTF (e). Two different are calculated for each RCTF: for the students and for the teachers. Positive values indicate that users are satisfied if a RCTF is used while negative values indicate that users are dissatisfied if a RCTF is used.

Finally, a scatterplot is created (see Fig. 3). Fig. 3 shows an illustrative example of a scatterplot with 15 different fictitious RCTF features.
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RCFT are positioned on the x-axis and the y-axis based on their $n_{et}$ and $n_{st}$ values, respectively. The scatterplot is split into four quadrants based on average values of $n_{et}$ and $n_{st}$ for all evaluated RCFT, namely $\bar{n}_{et}$ and $\bar{n}_{st}$. These quadrants help us to develop recommendations in the fourth activity.

In the fourth activity, recommendations for RCFT use are developed based on RCFT positions in the two scatterplots (one for lectures and the other for tutorials) and current RCFT status (i.e., in use, not in use, not implemented). First, RCFT are evaluated based on their position in the scatterplots by considering their $n_{et}$ value as either $T_{et}$ (teacher negative where $n_{et} < 0$) or $P_{et}$ (teacher positive where $n_{et} \geq 0$), and $n_{st}$ value as either $S_{st}$ (student negative where $n_{st} < 0$) or $P_{st}$ (student positive where $n_{st} \geq 0$). RCFT status also need to be considered to select an appropriate generic recommendation according to Table 1.

Second, detailed generic recommendations for RCFT that are in quadrant $T_{et}/P_{et}$ ($n_{et} \geq 0$ and $n_{st} \geq 0$) are selected as follows. The $T_{et}/P_{et}$ quadrant is further divided into four detailed quadrants (quadrants labeled from A to D in Fig. 3). RCFT can be either teacher low ($T_{L}$) when $n_{et} \geq 0$ and $n_{et} < \bar{n}_{et}$ or teacher high ($T_{H}$) when $n_{et} \geq \bar{n}_{et}$, and either student low ($S_{L}$) when $n_{et} \geq 0$ and $n_{et} < \bar{n}_{et}$, or student high ($S_{H}$) when $n_{st} \geq \bar{n}_{st}$. Finally, a detailed generic recommendation is selected according to the rules shown in Table 2 which also consider RCFT status.

The selected generic recommendations are the basis for further development into specific recommendations which are then given to teachers to improve their use of RCFT. Specific recommendations need to be developed for generic recommendations to better fit contextual factors, such as actual reasons for certain results, experience and teaching style of specific teachers, characteristics of students, specific needs of the course, etc. To develop specific recommendations for selected RCFT, different approaches can be used. For instance, additional discussion with teachers and/or students and additional analysis of the RCFT capabilities can help us better understand the problems that occur during the use of RCFT. Based on this understanding, we can better train teachers and/or students in use of RCFT and when possible also adapt RCFT to better suit their needs thus improving their satisfaction.

4. Test of the approach

In the next subsections, we present individual case studies from three different Universities. A description of the sample and a description of the results will be highlighted for each case separately.

4.1. Test design

The aim of testing was to determine how our proposed approach performs in real life university environment. Our approach was used in three different courses given by RCT at three different Slovenian public universities. We used an embedded multiple case study research design as defined by Yin (2017). In each case, the test was performed by using our approach to evaluate RCT in a selected course at one of the universities with two embedded units of analysis, namely lectures and tutorials. Each case study started with the first activity of the proposed approach, in which RCFT to be evaluated in later activities were identified. As a starting point for the discussion, a list of common RCFT (e.g., raising hands, whiteboard, live video, desktop sharing) was used in this activity. Participants discussed RCFT on the list. Additionally, similar, related, and unrelated RCFT that the participants came up with during the discussion based on their experience with online lectures and knowledge of different RCT were also discussed. This activity was followed by the preparation of the questionnaire and conducting the survey (second activity), analysis of survey results (third activity), and development of recommendations for improvement of RCT (fourth activity). More details on these activities in specific cases are provided in the description of each case study. After the four activities of the approach were completed, we discussed the results with teachers who performed the selected course to validate the results and usefulness of the approach. Additionally, we observed whether the given recommendations were followed by the teachers.

Table 1

| Quadrant | Status | Generic recommendation |
|----------|--------|------------------------|
| $T_{et}/P_{et}$ | All in use | Analyze the causes of students’ satisfaction and students’ dissatisfaction. Continue using this RCFT if students’ satisfaction can be improved. Otherwise, do not use this RCFT as teachers are dissatisfied with it. |
| $T_{et}/P_{et}$ | Not in use | Analyze the causes of teachers’ satisfaction and students’ dissatisfaction. Consider using this RCFT if students’ satisfaction can be improved. Otherwise, do not use this RCFT as students are dissatisfied with it. |
| $S_{et}/P_{et}$ | Not implemented in use | No changes. |
| $S_{et}/P_{et}$ | Not in use | Analyze the causes of students’ satisfaction and teachers’ dissatisfaction. Notice not using this RCFT if teachers’ satisfaction can be improved. Otherwise, consider not using this RCFT as teachers are dissatisfied with it. |
| $S_{et}/P_{et}$ | Not implemented | No changes. |

| Quadrant | Status | Generic recommendation |
|----------|--------|------------------------|
| $T_{et}/S_{et}$ | All in use | See detailed generic recommendations (Table 2) for high/low positive net satisfaction. |
| $T_{et}/S_{et}$ | Not in use | Analyze the causes of teachers’ satisfaction and students’ dissatisfaction. Continue using this RCFT if students’ satisfaction can be improved. Otherwise, consider not using this RCFT as students are dissatisfied with it. |
| $S_{et}/P_{et}$ | Not implemented in use | No changes. |
| $S_{et}/P_{et}$ | Not in use | Analyze the causes of students’ satisfaction and teachers’ dissatisfaction. Consider using the RCFT if students’ satisfaction can be improved. Otherwise, do not use this RCFT as teachers are dissatisfied with it. |
| $S_{et}/P_{et}$ | Not implemented | No changes. |

| Quadrant | Status | Generic recommendation |
|----------|--------|------------------------|
| $T_{et}/S_{et}$ | Analysis why this RCFT is in use and strongly consider not using this RCFT as no one is satisfied with it. |
| $T_{et}/S_{et}$ | Not in use | No changes. |
| $T_{et}/S_{et}$ | Not implemented | No changes. |
4.2. Ethical considerations

This study did not require approval from Institutional Review Boards according to the legislation of the Republic of Slovenia and internal acts of the University of Ljubljana, the University of Maribor, and the University of Primorska.

4.3. Case study 1

4.3.1. Description

We applied our approach in an elective course on software development in the master’s computer and information science study programme at the Faculty of Computer and Information Science at the University of Ljubljana. Lectures and tutorials took place in the second semester of the 2019/2020 study year. The lectures and tutorials were held weekly by a professor and three teaching assistants, respectively. The course was attended by 39 students. The course started in second half of February in a traditional way at the faculty premises. However, in the second half of March all faculty’s teaching activities moved online due to the worsening COVID-19 situation. All the remaining lectures and tutorials of the course were held on the BigBlueButton platform provided by the faculty. One of the

| Quadrant | Status               | Detailed generic recommendation                                                                 |
|----------|----------------------|--------------------------------------------------------------------------------------------------|
| T_H/S_H  | In use               | No changes.                                                                                      |
|          | Not in use           | Determine why this RCTF is not used. If possible, use this RCTF.                                 |
|          | Not implemented      | Determine if this RCTF can be implemented. If this RCTF can be implemented, implement and use it.|
| T_L/S_H  | In use               | Analyze the use of this RCTF to determine if satisfaction of students can be improved.          |
|          | Not in use           | Determine why this RCTF is not used and analyze the causes of lower students’ satisfaction. If possible, consider using this RCTF. |
|          | Not implemented      | Determine if this RCTF can be implemented and analyze the causes of lower students’ satisfaction. If possible, consider implementing and using this RCTF. |
| T_L/S_L  | In use               | Analyze the use of this RCTF to determine if satisfaction of teachers can be improved.          |
|          | Not in use           | Determine why this RCTF is not used and analyze the causes of lower teachers’ satisfaction. If possible, consider using this RCTF. |
|          | Not implemented      | Determine if this RCTF can be implemented and analyze the causes of lower teachers’ satisfaction. If possible, consider implementing and using this RCTF. |
| T_L/S_L  | In use               | Analyze the use of this RCTF to determine if satisfaction of students and teachers can be improved. |
|          | Not in use           | No changes.                                                                                      |
|          | Not implemented      | No changes.                                                                                      |

Table 2: Detailed generic recommendations for improvement of RCTF.

![Fig. 4. Scatterplot of students’ (x-axis) and teachers’ (y-axis) net satisfaction (n_e) for RCTF in Case 1.](image-url)
teaching assistants already finished his part of the tutorials in a traditional way before the second half of March. The whole course finished by the end of May.

Focus group consisting of teachers and students identified 11 relevant RCTF (described in the results section) in second half of May. These RCTF were included in the online survey executed at the end of May. Two teachers who participated in online teaching activities and 27 students completed the questionnaire (student response rate: 69.2%). The majority of the respondents (89.3%) were male. Age of students ranged from 22 to 26 years (M = 23.8, SD = 0.89). Recommendations for the use of RCTF were developed based on the survey results between June and July. In September, a focus group with the professor and two of the three teaching assistants was held to evaluate the results of the proposed approach.

4.3.2. Results

Fig. 4 shows net satisfaction ($n_e$) for RCTF evaluated in Case 1. The results are shown for lectures and tutorials using the same labels as presented in legend in Fig. 3. In both scatterplots all RCTF are in teacher and student positive quadrant ($T_P/S_P$) therefore Table 2 was used to provide detailed generic recommendations.

The recommendations were presented to a focus group of teachers who evaluated them and provided additional insights. Video annotations and magnifier were in quadrant D in both scatterplots and were not in use or were not implemented thus no changes were recommended. Similarly, no changes were recommended for feedback chat which was in use and in the quadrant A in both scatterplots. The focus group did not provide any additional insights for these elements. All the remaining RCTF are in quadrant B and quadrant C having different statuses. These RCTF are live videos, whiteboard, video modularization, playback, group support, push to talk, conduct a survey and share desktop. The focus group provided additional insights and specific recommendations for these RCTF as follows.

Students’ $n_e$ for live videos (in use) for tutorials (quadrant C) is high while teachers’ and students’ $n_e$ for lectures (quadrant D) are low, and teachers’ $n_e$ for tutorials is also low. The focus group pointed out that high bandwidth demand of live videos often causes problems for students who do not have high speed internet connections. This problem is somewhat more pronounced when a lot of students are connected to the same videoconference session (e.g., during lectures) while the problem is less visible when only a small group of students participate (e.g., during tutorials). Thus, evaluation of students’ $n_e$ with live videos in tutorials was higher than in lectures. Consequently, the teacher was advised to abandon live video during lectures and only keep live audio. The teachers followed this recommendation and only kept live audio during lectures.

Teachers’ and students’ $n_e$ for whiteboard (in use) for tutorials (quadrant A) are high while for lectures (quadrant B) students’ $n_e$ is low. The focus group suggested that, although whiteboard can help students to gain an understanding of complex course topics faster, in lectures they prefer pre-prepared presentations that are available for download. Based on this insight, the teachers were advised to continue using the whiteboard to help students to understand complex course topics faster while at the same time the pre-prepared presentations of such topics should be made available for download. The teacher partially followed this advice and provided downloadable presentations for some of the topics which he otherwise presented on whiteboard.

Teachers’ $n_e$ for video modularization (not implemented) for lectures (quadrant C) and tutorials (quadrant C) were low as they anticipated that such modularization would represent substantial additional work. However, students who were familiar with modularization from certain other courses evaluated $n_e$ for this RCTF as high. The focus group pointed out that in certain courses modularization approach was mostly performed automatically and required only little additional work. Teachers were advised to consult colleagues on how to effectively use video modularization and start using it. Nevertheless, this recommendation was not followed due to technical difficulties with the specific RCT used by the teacher.

Students’ $n_e$ for playback (in use during lectures, not in use during tutorials) were high while teachers’ $n_e$ were low for both lectures and tutorials (both quadrant C). The focus group pointed out that, although students prefer the ability to watch recorded lectures and tutorials that help them in learning, teachers do not favor recording lectures as they feel that consequently less students attend live lectures online. In our case, teachers recorded neither lectures nor tutorials. Based on the advice teachers tentatively started recording lectures. The attendance of online lectures was monitored for a month and the results showed that it did not drop significantly due to recording availability. Thus, the practice of recording lectures was permanently adopted by teachers in the course.

For group support (not in use) only teachers’ $n_e$ for tutorials (quadrant B) is high while teachers’ and students’ $n_e$ for lectures (quadrant D) are low, and students’ $n_e$ for tutorials is also low. High teachers’ $n_e$ in tutorials is mostly the consequence of the nature of tutorials that lean towards group work while lectures there is no such need for group work support during lectures. While teachers perceive RCT group support as an adequate tool and are satisfied with it, students’ $n_e$ for tutorials is low. The focus group suggested that students were familiar with different tools for group work already before tutorials and lectures switched online. These tools were typically advanced and offered additional functionality in comparison to group support included in RCT which resulted in lower student satisfaction. Teachers were recommended to examine the possibility of using additional tools for group support in tutorials that would supplement existing RCTF. The recommendation was followed and teachers started to use additional tools for group support in tutorials.

Teachers’ $n_e$ for push to talk (not implemented) are high while students’ $n_e$ are low for both tutorials and lectures (both quadrant B). Although teachers are satisfied with the ability to interact with students verbally, students prefer written communication using feedback chat (quadrant A). The focus group pointed out several advantages of feedback chat: it does not interrupt the teacher, students feel more relaxed and less exposed, and questions can be asked from noisy environment and without disturbing people in the same room. The latter was often the case as more people in the same room had to attend different online conferences (e.g., siblings attending different online lectures). As teachers $n_e$ for feedback chat was also high, the focus group recommended teachers to use feedback chat instead of push to talk whenever possible. The recommendation was followed and the teachers started using feedback chat as the main
means of communication during lectures and tutorials.

Teachers' $n_e$ for *conduct a survey* (in use) for lectures (quadrant B) is high while teachers' and students' $n_e$ for tutorials (quadrant D) are low, and students' $n_e$ for lectures is also low. The focus group noted that interactive communication with larger groups of students during lectures is difficult thus conducting a survey can be used to attract students' attention and increase their interaction. However, student groups are smaller during tutorials thus communication can be more direct. Further analysis showed that the RCTF offered sufficient functionality for teachers but only the basic functionality for students which resulted in low students' $n_e$. Thus, the focus group recommended teachers to substitute the RCTF with an advanced online survey tool that offers more attractive functionality for respondents (students). Although the recommendation was considered by the teacher it was not followed due to lack of integration with RCT which would considerably hinder its use during lectures.

Teachers' and students' $n_e$ for *share desktop* (in use) for tutorials (quadrant A) are high while for lectures (quadrant C) teachers' $n_e$ is low, and students' $n_e$ is high. The focus group determined that low teachers' $n_e$ in lectures is due to limited ability of the RCTF to share recorded videos that teachers would normally use in their physical lectures. As the RCTF only supports sharing video with low frame rates and without audio it was of limited use to the teachers. A possible solution for this situation recommended by the focus group would be to use a different RCT during lectures however the teacher did not want to change RCT that otherwise suited his needs. Later, he partially resolved this problem by sharing some of the video content on YouTube.

4.4. Case study 2

4.4.1. Description

The unit of analysis for the second case was an introductory course on information systems in criminal justice and security studies which started in late February and finished in late May 2020. The course was attended by 130 first year BA students at the University of Maribor. One lecturer carried out the lectures and one teaching assistant the tutorials. The first two lectures in late February and early March were held at the university. When the COVID-19 epidemic was declared in the middle of March, lectures switched to the Microsoft Teams platform provided by the university's central IT department. Tutorials started only after the epidemic was declared and were carried out solely online. Online teaching was restricted to the Microsoft Teams platform by a university rectorate decree.

Two focus groups were held with the teachers in early and middle May, and one focus group with the students in early May to identify important RCTF. Focus groups with students and teachers were conducted separately due to operational reasons. First, a focus group was conducted with the teachers who identified a set of eight relevant RCTF. Second, a focus group was conducted with students who identified two additional relevant RCTF. Third, the second focus group with the teachers was held to discuss the additional RCTF. By identifying another relevant RCTF related to the additional RCTF, the final set included 11 relevant RCTF. Based on the identified RCTF, a survey has been developed and conducted among both students and teachers in late May. Both teachers and 31 students responded (student response rate: 23.8%). The majority of respondents (54.8%) were female. Age of students ranged from 19 to 43 years ($M = 22.0, SD = 5.7$). All respondents used Microsoft Teams. Recommendations for the use of RCTF were developed between June and July based on the survey results. The results of the study were presented to the teachers in final focus group in December. The focus group was attended by the lecturer and the teaching assistant. The final focus group served to evaluate the results of the proposed approach.

Fig. 5. Scatterplot of students’ (x-axis) and teachers’ (y-axis) net satisfaction ($n_e$) for RCTF in Case 2.
4.4.2. Results

Fig. 5 shows net satisfaction (ne) for RCTF evaluated in Case 2. The results are shown for lectures and tutorials using the same scatterplot structure as Fig. 3. Two RCTF are not in teacher and student positive quadrant for lectures, and one of these also for tutorials. Based on Table 1, generic recommendations for these two RCTF were selected. All other RCTF are in teacher and student positive quadrant (TP/SP) therefore Table 2 was used to select detailed generic recommendations. In selecting the recommendations, the statuses of RCTF were considered.

The recommendations were presented to a focus group of teachers who evaluated them and gave further insights and specific recommendations. No changes were recommended for share desktop since it was in a quadrant A and in use during lectures and tutorials. Protection against monitoring of pedagogical activities was also in a quadrant A but it was not implemented. Although students and teachers agreed on the benefits of this RCTF, the focus group pointed out that no technical solutions exist that would completely eliminate the possibility of monitoring. Workarounds, such as alternative communication channels are possible but their use was not allowed by the university. Thus, no changes were recommended.

Students’ n_e for temporary video availability (not implemented) for tutorials and lectures (both quadrant E) is negative while teachers’ n_e for lectures is high, but for tutorials teachers’ n_e is low. Since temporary video availability was not implemented, no changes were recommended in line with the generic recommendations for improvement of RCTF. On the contrary view recorded videos of lectures (not in use) has high students’ n_e but negative teachers’ n_e for lectures (quadrant E), while for tutorials (quadrant A) teachers’ n_e is also high. The generic recommendations for improvement of RCTF indicate that the use of this feature for lectures should be considered if teachers’ satisfaction can be improved. The focus group pointed out that both RCTF are related to the availability of video recordings and that the results show that teachers disapprove these recordings for lectures although students find them helpful. The focus group indicated that video recordings would give teachers a sense of uncertainty and would make them uncomfortable while lecturing, increasing the stress related to not making any mistakes during lectures. According to the focus group, the key issue with recorded lectures is that the recordings can be edited. If the lecturer makes a mistake during the lecture and later corrects himself, the recording could be edited to only show the error without the correction. This could be then anonymously posted, for example, to social media to ridicule the lecturer (there were such cases at the faculty in the past). A legitimately recorded video may add to the perceived authenticity of such recordings. Therefore, no changes were recommended. The issue seems to be much less problematic for tutorials where the focus is on the procedure for a certain exercise or similar. Nevertheless, view recorded videos of lectures was cannibalized by download videos. Since pre-recorded videos give teachers better control over the contents and quality of the video than recording a livestream, no changes were recommended.

Students’ n_e for feedback chat (in use) for lectures (quadrant B) and tutorials (quadrant D) is low and teachers’ n_e for tutorials is also low while teachers’ n_e for lectures is high. The focus group noted that this RCTF is extensively used during lectures but only occasionally during tutorials as there are often better alternatives for communicating with the teacher (e.g., enabling the microphone, other communication channels). The results uncovered that students are less satisfied with this RCTF in average which was not expected by the teachers. It appears that although several students are regularly using this RCTF and may be satisfied with it, most students do not appreciate it. In lectures the teacher was recommended to adapt his use of this RCTF to engage better with the students and encourage the use of this RCTF among the less active students, while in tutorials teacher should use alternatives like microphone that are more suitable for smaller groups. The teachers followed these recommendations.

Students’ n_e for video annotations (not implemented) is low while teachers’ n_e is high for both tutorials and lectures (both quadrant B). The focus group found out that due to technological limitations this RCTF cannot be implemented on the Microsoft Teams platform however alternatives are in use (e.g., short videos, annotated videos on other platforms). Low students’ n_e may be a consequence of the alternatives’ inconsistencies therefore teachers were recommended to limit the number of alternative platforms if possible.

Students’ n_e for both manage video playback speed (not implemented) (quadrant D for lectures and quadrant B for tutorials) and conduct a survey (not implemented) for tutorials (quadrant B) and lectures (quadrant D) is low and teachers’ n_e for lectures is also low while teachers’ n_e for tutorials is high. The focus group pointed out that students did not perceive these RCTF as very beneficial and that due to the technical limitations it would be difficult to implement any of them. Thus, no changes were recommended for neither RCTF.

Students’ n_e for whiteboard (not in use during lectures, in use during tutorials) for tutorials (quadrant B) and lectures (quadrant D) is low and teachers’ n_e for lectures is also low while teachers’ n_e for tutorials is high. The focus group developed specific recommendations for this RCTF. No changes were recommended for lectures. However, the analysis showed that low students’ n_e for tutorials was primarily a consequence of poor RCTF performance (e.g., lag, different missing elements for different students). Therefore, teachers were advised to use alternatives during tutorials, such as Krita, Google Jamboard, etc. Teachers followed the focus group advice and started to use Google Jamboard in tutorials while in lectures no changes were implemented.

Students’ n_e for stream videos (not implemented) for lectures (quadrant C) and tutorials (quadrant A) is high and teachers’ n_e for tutorials is also high while teachers’ n_e for lectures is low. The focus group found out that it was only possible to stream video without audio due to the limitations of Microsoft Teams. Thus, no changes were recommended at the time. Nevertheless, soon after this issue was resolved by an update of Microsoft Teams that enabled the inclusion of computer sound while sharing content. However, the lecturer had a Linux operating system on his work computer, accessed Microsoft Teams through a browser and did not use a client therefore the update did not solve the issue resulting in a partial solution covering only tutorials.

Students’ n_e for download videos (not in use) for lectures (quadrant C) and tutorials (quadrant A) is high and teachers’ n_e for tutorials is also high while teachers’ n_e for lectures is low. The focus group found out that this RCTF is implemented but not used due to alternatives which are perceived as better by the teachers. For example, the lecture videos are published on the course website and tutorial videos are published on YouTube or Vimeo. The teachers noted that the alternatives offer good control over when the videos will be available to the students. Additionally, using other platforms helps to curb the potential surveillance by the university. Based on
these considerations, no changes were recommended.

4.5. Case study 3

4.5.1. Description

The unit of analysis for the third case was a course in statistics in second year of undergraduate study programme Applied kinesiology at the University of Primorska. The course was performed in the period from March to May 2020. Initially, the course started as one 5-h face-to-face lecture. Due to COVID-19 restrictions, it continued as online lectures performed in five sessions of 5-h, and online tutorials: six 5-h sessions. The course was attended by 44 students. Online sessions and consultations were performed via Cisco Webex and Jitsy platforms.

In early May 2020, a focus group with a lecturer and a teaching assistant was conducted, and in middle May 2020 another focus group with the students. Focus groups with students and teachers were conducted separately for operational reasons. First, a focus group conducted with the teachers identified a set of relevant RCTF. Second, a focus groups conducted with students confirmed the set of identified RCTF, and no additional relevant RCTF were identified. The two focus groups identified 11 relevant RCTF. These served as a reference for the online survey performed in late May. Both teachers and 28 students responded (student response rate: 63.6%). The majority of respondents (64.3%) were female. Age of students ranged from 20 to 24 years ($M = 20.8, SD = 1.0$). All respondents used both mentioned platforms. Recommendations for the use of RCTF were developed between June and July 2020 based on the survey results. In September, a final focus group with the lecturer and the teaching assistant was held to evaluate the results of the proposed approach.

4.5.2. Results

Fig. 6 shows net satisfaction ($n_e$) for RCTF evaluated in Case 3. The results are shown for lectures and tutorials using the same labels as presented in legend in Fig. 3. In both scatterplots all RCTF are in teacher and student positive quadrant ($T_P/S_P$) therefore Table 2 was used to provide detailed generic recommendations.

Similar to Case 1, RCTF in quadrant B and quadrant C, i.e., having either high teachers’ or low students’ $n_e$ or vice versa (i.e., video modularization, playback, live videos, magnifier, whiteboard), are examined in detail. Furthermore, specific recommendations that can potentially be adopted by the stakeholder group with lower $n_e$ are presented.

Students’ $n_e$ for video modularization (not in use) and playback (not in use) is low for both lectures and tutorials (both quadrant B) while teachers’ $n_e$ is high. The detailed analysis of the situation indicates that students are not aware of all RCTF simply because they were not used in practice. As this group of students are not engineering students, their knowledge in RCTF is relatively low hence they do not recognize the value of these two RCTF. From teachers’ perspective, despite the relatively high $n_e$, this RCTF was not used in practice as lectures were not prepared to introduce another innovation in their lectures and tutorials in such short time. Nevertheless, further attention should be worth considering implementing these RCTF and monitor its use by students. The focus group recommended that these two RCTFs should first be tested in practice with students: to enable playback and to prepare and provide students with some examples of modularized videos. However, this recommendation was not followed because in the studied institution the...
recording of lectures and tutorials was prohibited during the research.

High teachers’ $n_t$ in contrast to low students’ $n_e$ is present also for group support (not in use during lectures, in use during tutorials) for lectures and live video (in use) for tutorials (both quadrant B). The rationale for these results can be found in the design of lectures where the group work is minimized or even non-existent, and tutorials where the focus is on tasks/exercises performed through shared desktop and in many situations in groups. The first recommendation was to implement group support also during lectures whenever possible, and monitor the use of this RCTF, especially by students. However, the teachers should consider the possibilities for use of this RCTF and redesign lectures accordingly before implementing the recommendation. In the endeavor of moving the focus from teachers’ teaching to students independent learning, the involvement of students in group work represents an important element of active learning. The focus group recommended identifying situations where group work could be used with RCTF group support, particularly where significant additional resources and significant curriculum redesign are not required. Teachers put this recommendation into practice. The second recommendation was to monitor the use of live videos by students in case of tutorials. This monitoring would provide information which would help to improve students’ $n_e$. The recommendation was followed. Monitoring was done by interviewing some students, who confirmed that the focus of tutorials is on sharing the desktop. In many cases, students also hide the live video with the lecturer so that only the audio can be heard.

Magnifier (not implemented) has high students’ $n_e$, as opposite to low teachers’ $n_t$ for both lectures and tutorials (both quadrant C). Teachers who would normally use a physical blackboard/whiteboard and a projector to show their presentations did not see the benefits of using a magnifier when giving lectures online. They considered magnifier as an unnecessary distraction. On the other hand, students who were often using devices with smaller screen (e.g., laptops, tablets, even smartphones) considered magnifier as a possible solution that would enable them to better follow the lectures. The recommendation was to implement this RCTF and present the advantages of its use to teachers. The recommendation was followed. Moreover, teachers started to use this RCTF and confirmed that they became more attentive to visibility on the “other side of the screen.”

In case of tutorials, whiteboard (in use) (quadrant C) has high students’ $n_e$, as opposite to low teachers’ $n_t$. Teachers who were otherwise used to a physical blackboard/whiteboard found this RCTF difficult to use so they used it only seldom. However, students perceived this RCTF as very helpful as it made lectures easier to follow. The analysis revealed that teachers were not aware of the RCTF importance for students. Obviously, this RCTF to some extent simulates the physical blackboard/whiteboard that students are used to. The recommendation was to inform teachers about importance of this RCTF and encourage them to use it more frequently. The recommendation was followed and both teachers increased the use of whiteboard.

5. Discussion

In all three case studies the proposed approach provided non-trivial and relevant insights and recommendations to teachers that helped them to make better decisions regarding RCT for distance learning. The evaluation of RCTF from teachers’ and students’ perspectives enabled the identification of RCTF, the use of which would provide most benefits in online teaching. The concurrent consideration of the two stakeholders’ views helped identify the RCTF with highest potential for improvement, i.e., RCTF that have either low students’ and teachers’ $n_e$ or low teachers’ and high students’ $n_e$. This answers RQ1 and RQ2, and confirms RQ3. Next, the evaluation results were used to select the generic recommendations which proved to be suitable starting points for a structured and more in-depth analysis of RCTF use. Based on this in-depth analysis, concrete specific recommendations for RCTF use were developed and presented to teachers in all three cases. This confirms RQ4.

Additionally, we observed whether the given recommendations were followed by the teachers. In three studied cases, 22 recommendations were provided in total. Out of these 22 recommendations, 15 were followed fully, three were followed partially, and four were not followed. These results additionally indicate that our approach can create concrete recommendations that can be successfully used in practice. Nevertheless, we also examined the reasons why the recommendations were not followed or were followed only partially. The most frequent reason that a recommendation was not followed, were technical difficulties that hindered implementation of recommendation, next, a recommendation might require considerable effort to implement and was thus implemented only partially and finally, some of recommendations were not implemented due to limitations of institutional policy.

Application of the approach in three different cases clearly demonstrated its benefits and showed that RCTF use should be adapted to the specifics of each course where lectures and tutorials need to be considered separately. Even when focus groups from the three case studies identified identical RCTF (e.g., whiteboard), the evaluation of such RCTF notably differed between the case studies. This indicates that it is not possible to set general rules which RCTF should be used in all courses but that RCTF should be evaluated and analyzed for each course individually.

Additionally, it is important to consider that students and teachers gain experience in RCTF use over time and that according to Kano (Kano et al., 1984) we can expect RCTF to shift between quality categories. For example, RCTF that are currently attractive will gradually move to one-dimensional, and finally to must-be. Thus, the proposed approach may be used regularly to detect such changes in teachers’ and students’ $n_e$ and provide new recommendations when needed.

Some limitations should be considered when applying our approach in practice. According to Bastable (2008), three broad categories of barriers need to be addressed in evaluation: lack of clarity, lack of ability, and fear of punishment or loss of self-esteem. To address the lack of clarity, the purpose of evaluation must be clearly stated to participating students and teachers who should understand that their opinion is vital to improve the use of RCT. Also, all RCTF must be clearly presented to students and teachers so that they can objectively evaluate them. It is important that students and teachers clearly understand that they evaluate their satisfaction with RCTF at a certain course, and not in general. To address lack of ability, evaluators should have good understanding of the approach, should be able to guide focus groups in identification of the RCTF for evaluation, and should have sufficient expertise in
evaluation and analysis. To address fear of punishment and loss of self-esteem, it should be clearly explained to evaluation participants that there are no right and wrong answers, so they do not perceive evaluation as a judgment of personal worth. This is even more important for teachers as their participation is not anonymous as in the case of students.

6. Conclusion

The proposed approach proved to provide useful insights and recommendations to improve the use of RCT in higher education. This is especially important during the COVID-19 pandemic when most of higher education institutions switched to distance learning and RCT became one of the key teaching technologies. The approach was successfully used in three case studies. Although the approach was developed within the pandemic context, we believe that it can provide useful recommendations and insights also in other situations when RCT are used in higher education.

However, two important limitations of this study need to be considered. First, we were unable to conduct more case studies as our resources were limited. Nevertheless, Yin (2017) states that three or more case studies present a strong argument. Second, although the three case studies were performed at three different higher education institutions, all three are located in Slovenia. Thus, it is not clear whether the approach can be successfully applied in countries with significantly different cultural backgrounds.

During the COVID-19 pandemic, there is no physical communication alternative to the use of RCT. Therefore, it is even more important to better understand how different RCTF help students attain learning objectives. Thus, future work may focus on the impact of different RCTF on attainment of higher level learning objectives according to Bloom’s taxonomy (Bloom et al., 1956). Based on these findings, the proposed approach may be expanded to also consider the effectiveness of different RCTF in terms of attaining target learning objectives. Finally, it would be interesting to gain insights into how teachers’ experience and teaching style influence their preferences for different RCTF.

Credit author statement

Damjan Fujs: Conceptualization, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. Simon Vrhovec: Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. Boštjan Žvanut: Formal analysis, Investigation, Validation, Writing – original draft. Damjan Vavpotič: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Research Management, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

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