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CoRad-19 – Modular Digital Teaching during the SARS-CoV-2 Pandemic

CoRad-19 – Modulare Digitale Lehre während der SARS-CoV-2-Pandemie

Authors

Andreas Stefan Brendlin[1], Isabel Molwitz[2], Thekla Helene Oechtering[3, 4], Jörg Barkhausen[4], Alex Frydrychowicz[4], Tanja Sulkowski[4], Maren Friederike Balks[4], Michael Buchholz[4], Stefan Lohwasser[5], Martin Völker[5], Olaf Goldschmidt[5], Anja Johenning[5], Sabine Schlender[5], Christian Paulus[5], Gerald Antoch[6], Sabine Dettmer[7], Bettina Baeßler[8], David Maintz[9], Daniel Pinto dos Santos[10], Thomas J. Vogl[10], Elke Hattingen[11], Dietrich Stoevesandt[12], Sebastian Reinartz[13], Corinna Storz[14], Katharina Müller-Peltzer[15], Fabian Bamberg[15], Fabian Rengier[16], Meike Weis[17], Anne Frisch[18], Nienke Lynn Hansen[19], Manuel Kolb[1], Michael Maurer[1], Konstantin Nikolaou[1], Saif Afat[1], Ahmed E. Othman[1, 20]

Affiliations

1 Department of Diagnostic and Interventional Radiology, Eberhard-Karls University, Tuebingen, Germany
2 Department of Diagnostic and Interventional Radiology and Nuclear Medicine, University Medical Center Hamburg-Eppendorf, Hamburg, Germany
3 Department of Radiology, University of Wisconsin-Madison, Madison, United States
4 Department of Radiology and Nuclear Medicine, University Hospital Schleswig-Holstein, Lübeck, Germany
5 German Roentgen Society „Deutsche Röntgengesellschaft“, Berlin, Germany
6 Department of Diagnostic and Interventional Radiology, University Hospital Essen, Essen, Germany
7 Department of Diagnostic and Interventional Radiology, Hannover Medical School, Hannover, Germany
8 Institute of Radiology, University of Würzburg, Würzburg, Germany
9 Department of Radiology, University Hospital of Cologne, Cologne, Germany
10 Department of Diagnostic and Interventional Radiology, University Hospital Frankfurt, Frankfurt am Main, Germany
11 Institute of Neuroradiology, University Hospital Frankfurt, Frankfurt am Main, Germany
12 Department of Radiology, Martin Luther University Halle-Wittenberg, Halle, Germany
13 Department of Diagnostic and Interventional Radiology, RWTH Aachen University, Aachen, Germany
14 Department of Neuroradiology, University Medical Center Freiburg, Faculty of Medicine, University of Freiburg, Freiburg, Germany
15 Department of Diagnostic and Interventional Radiology, University Medical Center Freiburg, Faculty of Medicine, University of Freiburg, Freiburg, Germany
16 Clinic for Diagnostic and Interventional Radiology, Heidelberg University Hospital, Heidelberg, Germany
17 Department of Radiology and Nuclear Medicine, Medical Faculty Mannheim, University Medical Center Mannheim, Heidelberg University, Mannheim, Germany
18 Department of Diagnostic and Interventional Radiology, Charité, Berlin, Germany
19 Department of Diagnostic and Interventional Radiology, MVZ Rheinlandärzte GmbH, Willich, Germany
20 Department of Neuroradiology, University Medical Center, Mainz, Germany

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Correspondence

Dr. Saif Afat
Diagnostische und Interventionelle Radiologie, Universitätsklinikum Tübingen, Hoppe-Seyler-Strße 3, 72076 Tübingen, Germany
Tel.: +49/0 70 71/2 96 84 23
saif.afat@med.uni-tuebingen.de

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ABSTRACT

Purpose During the SARS-CoV-2 pandemic, higher education worldwide had to switch to digital formats. The purpose of this study was to evaluate CoRad-19, a digital teaching tool created by the German Radiological Society for medical students during the COVID-19 pandemic.

Materials and Methods A total of 13 German-speaking universities implemented CoRad-19 in their curriculum and partially or completely replaced their classes with the online courses. Previous experience and contact with radiology and the participants' opinions regarding the medium of e-learning were surveyed using a custom questionnaire. The subjective level of knowledge regarding the individual modules was also surveyed before and after participation to measure learning effects. The data of 994 medical students from the participating sites were analyzed and compared intraindividually using the Friedman test.

Results From 4/1/2020–10/1/2020, 451 complete data sets from a total of 994 surveys were included. E-learning was rated "very useful" both before and after course participation (4 [IQR 3–4], $p = 0.527$, $r = 0.16$). E-learning as a method was also rated as a "very good" medium both before and after participation (4 [IQR 3–4], $p = 0.414$, $r = 0.17$). After participation, participants rated radiology as particularly suitable for digital teaching (before: 3 [IQR 3–4] vs. after 4 [IQR 3–4], $p = 0.005$, $r = 0.6$). Significant learning gains were measurable in all course modules ($p \leq 0.009$). Post-hoc analysis showed interest in radiology to increase significantly after course participation ($p = 0.02$).

Conclusion In the representative survey, significant learning effects were observed in all course modules. In addition, it should be particularly emphasized that the students' interest in radiology was increased by course participation. Thus, the German Radiological Society provided significant support to German-speaking medical faculties with respect to maintaining excellent education using CoRad-19.

Key Point:

- Co-Rad-19 course participation results in measurable subjective learning effects and increases student interest in radiology.

Citation Format

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ZUSAMMENFASSUNG

Ziel Während der SARS-CoV-2-Pandemie musste die Hochschullehre weltweit auf digitale Formate umstellen. In dieser Studie sollte CoRad-19, ein im Rahmen der COVID-19-Pandemie erstelltes digitales Lehrangebot der Deutschen Röntgengesellschaft (DRG) für Medizinstudierende, evaluiert werden.

Material und Methoden Insgesamt 13 deutschsprachige Hochschulstandorte haben CoRad-19 in ihr Curriculum implementiert sowie ihre Lehrangebote teilweise oder sogar vollständig durch die Online-Kurse ersetzt. Mithilfe eines eigens entworfenen Fragebogens wurden Vorerfahrungen in und bisherige Kontakte zur Radiologie erfragt sowie die Meinung der Teilnehmenden gegenüber dem Medium E-Learning erhoben. Als Maßstab für den Lernerfolg wurde der subjektive Kenntnisstand bezüglich der einzelnen Module jeweils vor und nach der Teilnahme erhoben. Die Angaben 994 Medizinstudierender aus den beteiligten Standorten wurden analysiert und mittels Friedman-Test intraindividuell verglichen.

Ergebnisse Vom 01.04.2020–01.10.2020 wurden aus insgesamt 994 Erhebungen 451 vollständige Datensätze inkludiert. E-Learning wurde sowohl vor als auch nach der Teilnahme an den Kursen als „sehr sinnvoll" eingeschätzt (4 [IQR 3–4], $p = 0{,}527$, $r = 0{,}16$). Auch E-Learning als Methode wurde sowohl vor als auch nach der Teilnahme als „sehr gutes" Medium bewertet (4 [IQR 3–4], $p = 0{,}414$, $r = 0{,}17$). Nach Teilnahme an den Kursen schätzten die Teilnehmenden die Radiologie als besonders geeignet für digitale Lehre ein (vorher: 3 [IQR 3–4] vs. nachher 4 [IQR 3–4], $p = 0{,}005$, $r = 0{,}6$). In allen Kursmodulen waren signifikante Lernerfolge messbar ($p \leq 0{,}009$). Eine Post-hoc-Analyse zeigte, dass das Interesse an der Radiologie nach Teilnahme an den Kursen signifikant zunahm ($p = 0{,}02$).

Schlussfolgerungen In der repräsentativen Umfrage wurden signifikante Lerneffekte in allen Kursmodulen beobachtet. Zudem ist besonders hervorzuheben, dass das Interesse der Studierenden an der Radiologie durch die Kursteilnahme gesteigert werden konnte. Die DRG konnte den deutschsprachigen medizinischen Fakultäten durch CoRad-19 also wichtige Unterstützung bei der Aufrechterhaltung exzellenter Lehre bieten.

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Introduction

On 1/30/2019 the World Health Organization (WHO) declared COVID-19a global emergency [1]. In spite of significant efforts, SARS-CoV-2 spread around the globe resulting in at least 102,177,365 cases and 2,209,313 confirmed deaths globally on the first anniversary of the pandemic [2]. Contact restrictions and social distancing are necessary to break the chain of infection. Consequently, at the height of the first wave in Europe, up to 85 % of universities were not able to provide in-person learning because they could not meet the strict hygiene requirements [3]. In addition to the significant impact on everyday life, the pandemic also resulted in significant restrictions in medical education [4]. To avoid jeopardizing the education of students in the medium term, higher education in Germany was forced "from the status quo into the digital world without proper preparation" [5, 6]. High-quality and effective digital teaching requires well-thought-out digital course offerings and an adequate technical infrastructure [7]. However, the development and use of corresponding structures vary between individual sites [8]. To provide ad hoc support to German-speaking medical faculties

in this situation, the German Radiological Society developed a course system tailored to the main university course content called "CoRad-19" at the start of the pandemic [9, 10]. The nine modular courses are comprised of a combination of lectures, theoretical questions, and interactive cases and can be implemented by universities individually or as a complete package to supplement any already offered courses. 13 medical schools in Germany, Switzerland, and Austria decided to implement CoRad-19. While some universities only used individual course modules, others replaced their entire radiology program with the CoRad-19 courses. The goal of this study was to systematically determine how students feel about e-learning, particularly in regard to radiology, and whether measurable learning gains can be achieved with CoRad-19.

Materials and Methods

Target group

The target group included the participants in the CoRad-19 course modules at all participating universities. The study includes the period from April 1, 2020 to October 1, 2020. In terms of demographic data, we recorded the participants' native language, gender, and age.

Survey and course modules

We asked participants about their prior experience and contact with radiology and about their general opinion of e-learning and if they had previously participated in digital courses. Participants were asked immediately before and after completion of a course module to anonymously evaluate their personal performance. A 4-point Likert scale (1 = disagree, 2 = tend to disagree, 3 = tend to agree, 4 = agree) was used for the self-evaluation regarding every learning objective of the nine course modules (see ▶ **Table 1**). Due to the anonymous nature of the survey, it was not necessary to obtain ethics committee approval.

Statistics

Statistical analyses were performed with IBM SPSS Statistics Version 27 for Windows (Armonk, NY, USA). Normally distributed variables are given as mean ± standard deviation (SD), not normally distributed variables as median and interquartile range (IQR).

To improve accuracy, we focused on intraindividual comparisons in the individual modules. Data sets with missing values in the individual categories were excluded. Normally distributed variables were analyzed with a one-way repeated measure ANOVA, and not normally distributed variables were analyzed with the Friedman test. An alpha correction according to Dunn-Bonferroni was performed for the post-hoc tests. A p-value of < 0.05 was considered statistically significant. We calculated the Pearson's correlation coefficient as a measure of the effect size (r). Values from 0.1 to 0.3 indicated a small effect size, from 0.3 to 0.5a moderate effect size, and ≥ 0.5a significant effect size.

For better comparability and optimized representation, we summarized the self-evaluations regarding individual learning objectives for each course. In addition, we calculated what percentage of participants gave a positive response (3 or 4) before and after the modules and calculated the difference as an indicator of learning gains.

Results

Target group

At the time of the analysis, a total of 994 students had completed the self-evaluation. 451 complete data sets were included and evaluated intraindividually (45 %). The average age of the participants was 25 ± 4 years.. The gender distribution was as follows: 152 male, 273 female, 26 not specified. German was specified as the native language among 87 % of the participants, Italian among approximately 4 %, French among 3 %, English among 1 %, and other languages among 5 %. See ▶ **Fig. 1** for further details.

Opinions regarding e-learning

E-learning was rated as "very useful" both before and after participation in CoRad-19 (4 [IQR 3–4], $p = 0.527$, $r = 0.16$). E-learning as a method was also rated as a "very good" medium both before and after participation (4 [IQR 3–4], $p = 0.414$, $r = 0.17$). However, it is noteworthy that significantly more students rated radiology as particularly suited for digital teaching after participation (before: 3 [IQR 3–4] vs. after 4 [IQR 3–4], $p = 0.005$, $r = 0.6$). ▶ **Fig. 2** shows a graphic of the opinions of students regarding e-learning before and after participation in our courses.

Courses

The intraindividual evaluation of the course modules showed that the self-evaluation by participants was significantly higher after completing the courses than before (≥ 10 % learning gain, Friedman Test: $\chi^2(1) > 6.8$, $p \leq 0.009$, $n \geq 120$). There were no differences between participants regarding native language, gender, age, and previous experience in radiology ($p = 0.861$). The greatest learning gains were achieved in the course modules "pediatric radiology" (47 %, $p < 0.001$, $r = 0.67$) and "musculoskeletal radiology" (44 %, $p < 0.001$, $r = 0.66$). The observed effect was low ($r = 0.24$) only in the thematically mixed final course "radiological routine", which included various cases from all areas. However, the self-evaluation prior to participation in the final course was significantly higher compared to the self-evaluation prior to the start of the other courses ($p < 0.025$). See ▶ **Fig. 3** for further details.

Post-hoc analysis of the learning objectives

Particularly high subjective learning effects were achieved for the learning objective "pathologies and tumors" in the module "musculoskeletal radiology" (72 %) and for the learning objective "typical pathologies" in the module "pediatric radiology" (68 %)(in each case $p < 0.001$, $r > 0.7$; see suppl. **Table 1**). We saw the lowest effect (10 % learning gain) in the thematically mixed final course "radiological routine" (before 3 [IQR 2–3], after 3 [IQR 3–3], $r = 0.24$) in spite of significant improvement. In this module the post-hoc analysis did not show any changes regarding the learning objectives "anatomy" (before 3 [IQR 3–3], after 3 [IQR 3–3]; $p = 0.763$), "pathology" (before 3 [IQR 2–3], after 3

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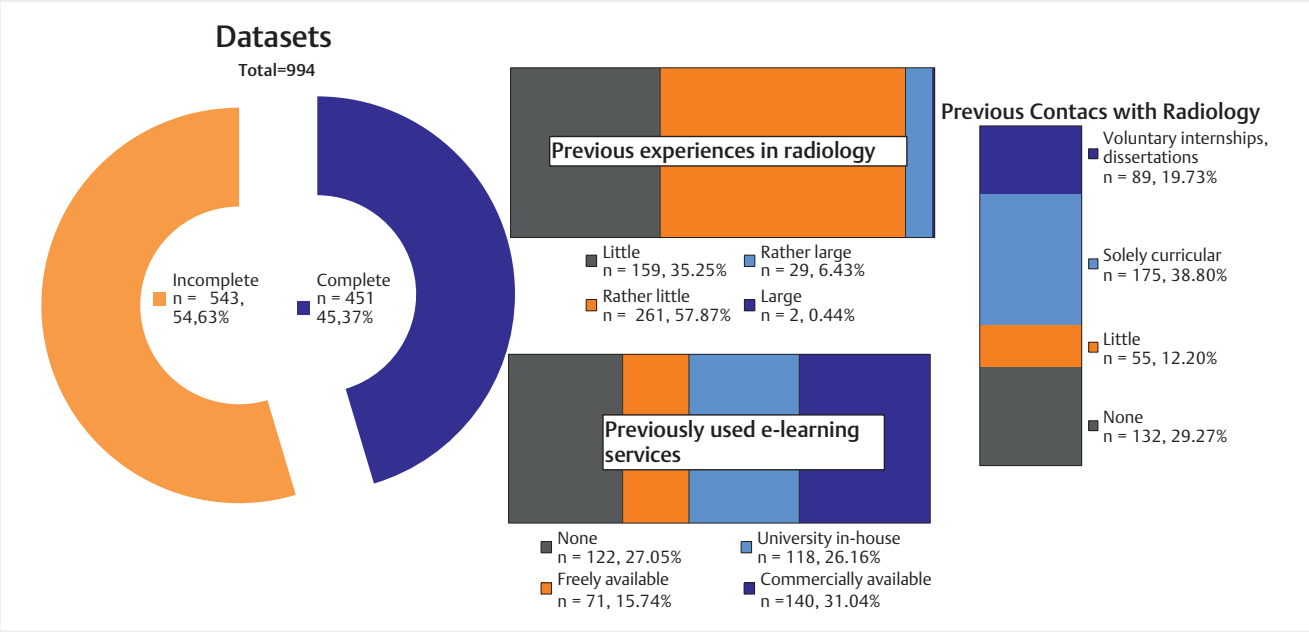
▶ **Table 1** Course modules and learning objectives.

Course modules and learning objectives	Thematic self-evaluations
Technology & radiation protection	
Sonography, radiation protection, layout and function of an X-ray tube, layout of a CT scanner, Hounsfield scale, functionality of an MRI scanner, T1 and T2 weighting	8
Thorax radiology	
Anatomy, CT, morphological pathologies in pulmonary artery embolism and pneumothorax	6
Abdominal radiology	
Anatomy, morphological aspects of cysts and changes in the aorta	5
Angiography & interventions	
Anatomy, biopsy and intervention, general pathology, and indications	4
Pediatric radiology	
Anatomy, systematics, typical pathologies	4
Gynecological radiology	
Systematics, sensitivity, typical pathologies	4
Musculoskeletal radiology	
Bones in different modalities, arthrosis, fractures, tumors	5
Neuroradiology	
Ischemia, disc prolapse	3
Final course "Radiological Routine", mixed topics	
Anatomy, systematics, typical pathologies, interest in the field of radiology	4
= Total	43



▶ **Fig. 1** Data sets, previous experience, e-learning offerings used, contact with radiology.

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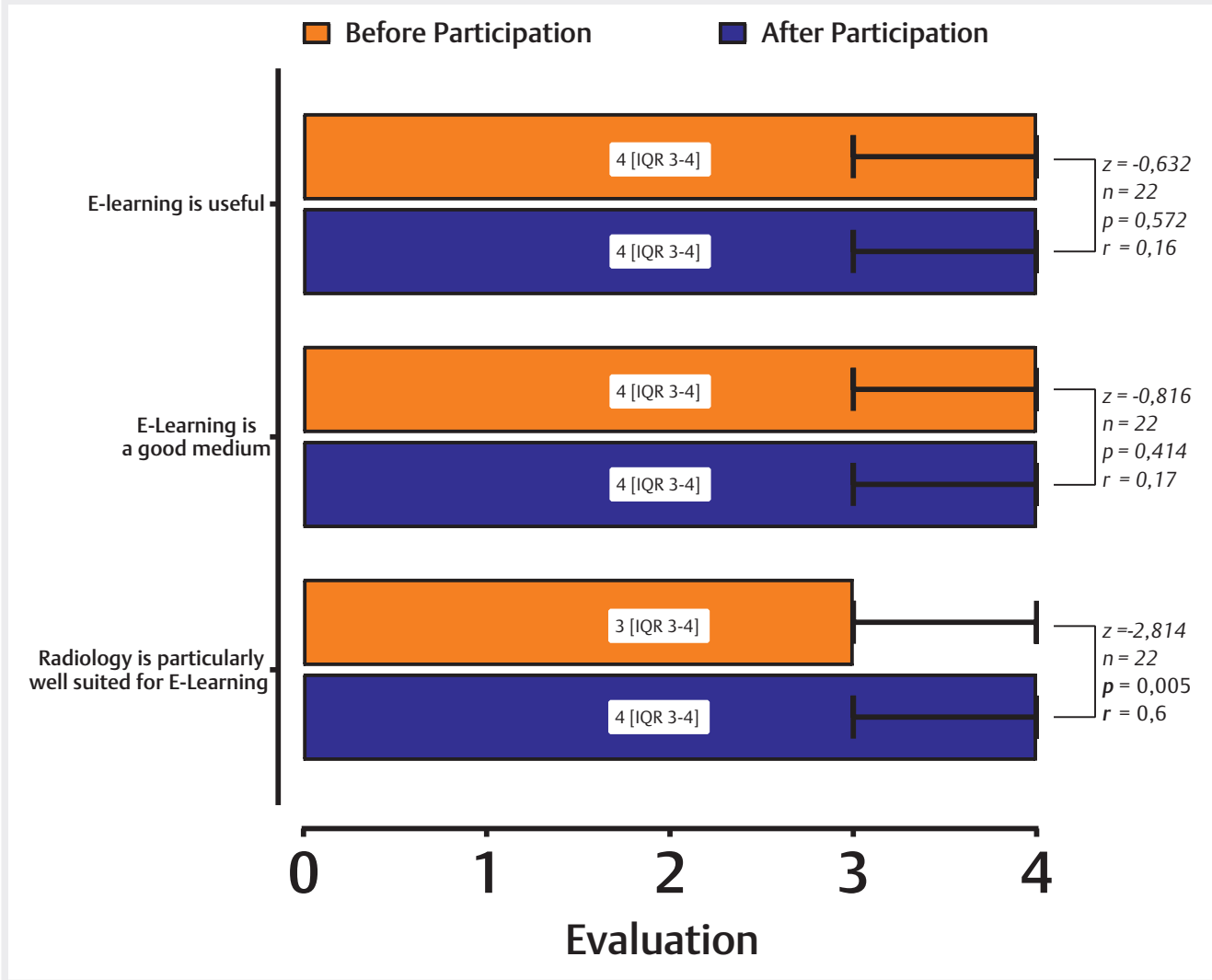

▶ **Fig. 2** Opinions regarding e-learning.

[IQR 3–3]; $p = 0.285$), and "systematics" (before 3 [IQR 2–3], after 3 [IQR 3–3]; $p = 0.109$). However, a significant improvement was observed regrading participants' general interest in the field of radiology (before 3 [IQR 2–3], after 3 [IQR 3–4]; $p = 0.02$). ▶ **Fig. 4** shows the self-evaluations regarding the learning objectives in the final course "radiological routine" before and after participation in the course module.

Discussion

E-learning is an integral part of modern teaching. Even before the COVID-19 pandemic, many students participated in digital learning on a supplementary basis. However, the focus in medical education was on in-person learning. Because of the pandemic, universities around the world had to fundamentally change their courses without warning. The goal of this representative survey was to assess the self-evaluations of medical students who had completed the CoRad-19 course system provided by the German Radiological Society. We evaluated how the participants feel about e-learning and whether the modular course system CoRad-19 results in measurable learning gains. The students we surveyed had a highly positive view of digital teaching both before and after participation in CoRad-19. Other current studies also reflect a positive attitude on the part of students toward digital teaching. For example, Sud et al. showed that 97.2 % of the students they surveyed see Web-based teaching methods as an adequate alternative to in-person learning [11]. After participation in CoRad-19, significantly more participants were convinced that radiology is particularly suitable for digital teaching. This coincides with the results of other studies. For example, Häusler et al. were able to show that radiology lectures and seminars can be implemented particularly effectively using a digital format [12]. However, as in other studies, Häusler et al. came to the conclusion that digital lectures and seminars are less suitable for teaching practical skills due to the low level of interactivity [13, 14]. The reporting of findings, one of the most important practical skills in radiology, is performed, however, almost exclusively digitally in the daily routine. Therefore, with corresponding interactivity, radiology reporting can be effectively taught and learned on a digital basis. Nevertheless,

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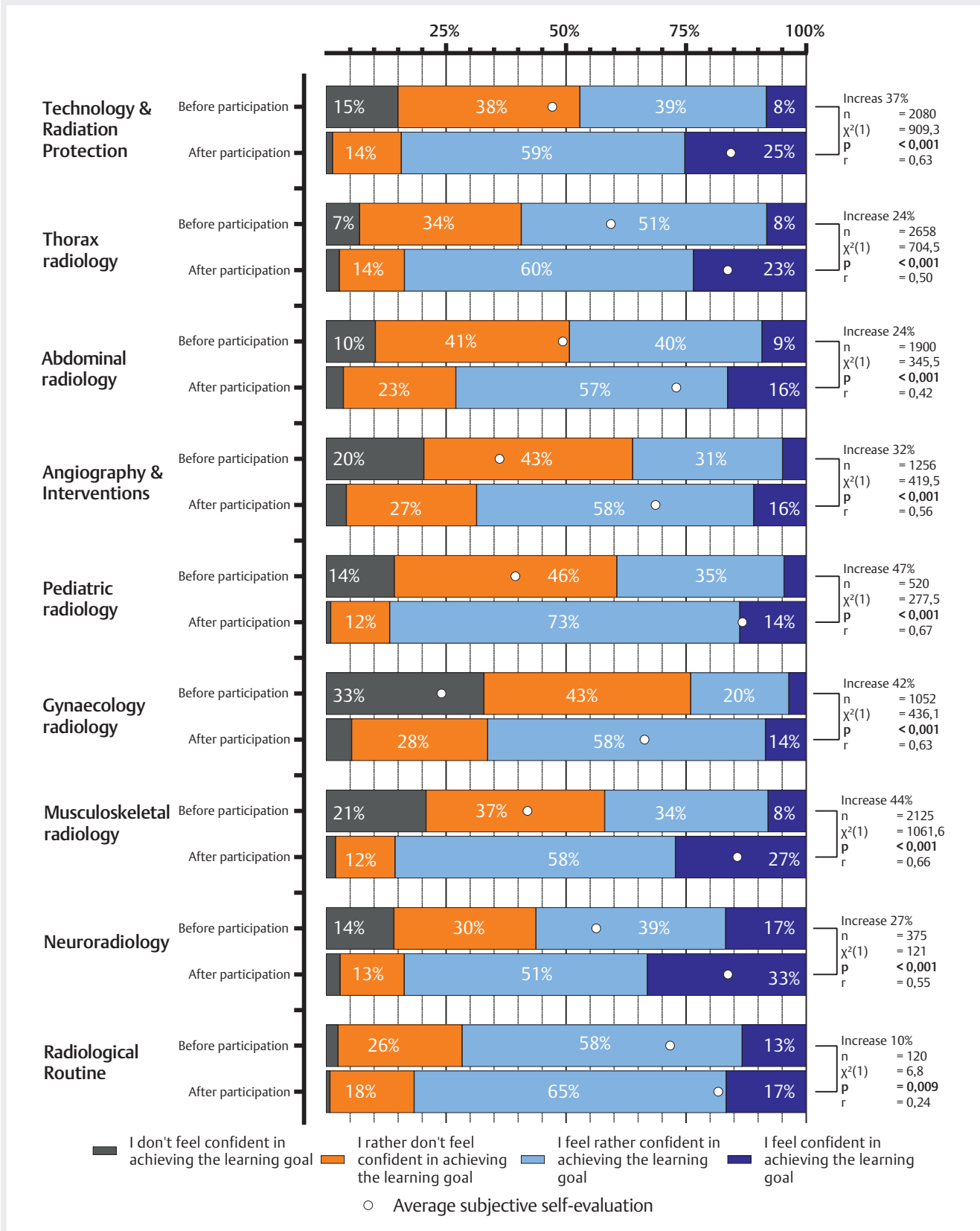

▶ **Fig. 3** Summarized self-evaluation regarding course learning objectives (n = assessments * learning objectives).

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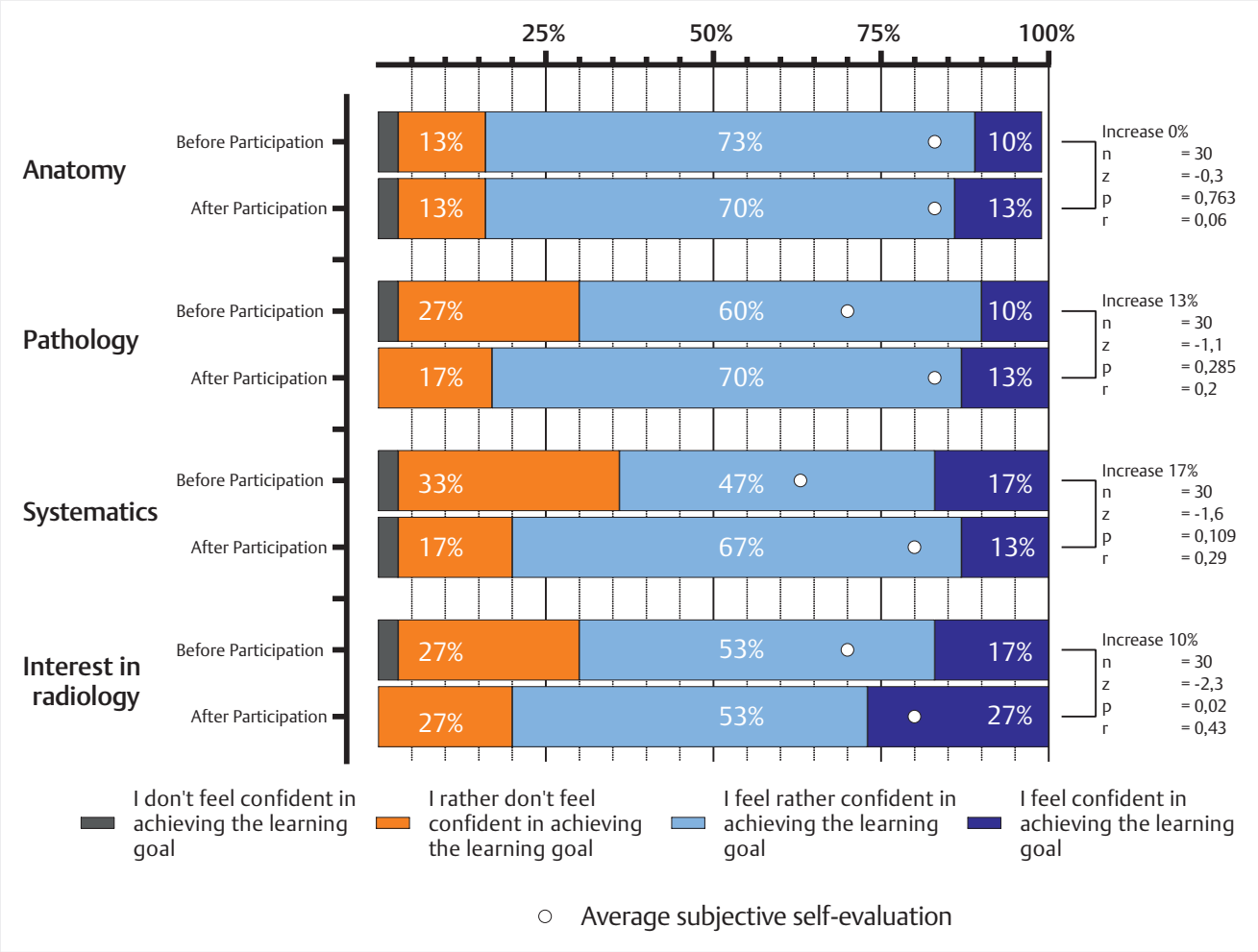

▶ **Fig. 4** Post-hoc analysis "Radiological Routine" before and after completion of the course.

digital teaching formats in radiology must comply with data security and structural requirements. Therefore, in comparison to other disciplines, much larger volumes of data per patient and examination must be able to be stored and must also be able to be retrieved as dynamically and interactively as possible [15]. In publications in other disciplines, the conversion to purely digital teaching was described as particularly challenging due to insufficient technical infrastructure [16]. In contrast, the radiological technical infrastructure was already comparably well-established prior to the pandemic because it is a necessity in radiology. This presumably greatly facilitated the seamless development and implementation of CoRad-19 [15]. Nonetheless, optimism tends to be mixed with caution with respect to the prompt implementation of digitalization in other disciplines in Germany [6]. We conclude that radiology is suitable for digital teaching. However, it should be noted that radiology's technical requirements made it particularly well prepared for a conversion to digital teaching. Like other research groups, we were also able to establish that digital teaching results in measurable subjective learning gains. For example, Kaur et al. were able to show that digital teaching methods were almost exactly as effective among medicine students during the pandemic as classic in-person learning [17]. Backhaus et al. indicated that students with a digital affinity have a significantly more difficult time adjusting to traditional lecture formats than less digitally oriented students [18]. Given the general increases in digitalization, future generations could see greater implementation of digital teaching. However, Wilcha et al. correctly criticized that exclusively digital courses are associated with less interaction between students and between students and teachers [5]. Yet, working on cases together in learning groups could actually increase discipline-specific interaction compared to traditional in-person learning. Häusler et al. concluded in their study that a digital teaching unit should be thematically strictly limited to the learning objectives [12]. Our results showed significant subjective learning gains in all topic-specific course modules. The effect size of these significant improvements in the thematically mixed final module "radiological routine" was the lowest among all courses. However, this comparatively less pronounced effect can be explained by the fact that the self-evaluation was significantly higher in this module than in all other modules already before participation. Therefore, it can be argued that the other courses had prepared the participants for the questions in the final course. The significantly increased by comparatively lower learning gains in this module are presumably due to its position as the

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final course. Participation in the CoRad-19 course program resulted in an increase in the interest of participants in the field of radiology. In light of the current talent shortage in all medical fields and professional societies, good digital teaching should be prioritized – not just for our own professional society but also for other medical associations and organizations. This study has a few limitations. The individual faculties were able to decide for themselves which course modules to implement and how to adapt their own curriculum to the courses. This resulted in unequal use of the individual modules. A standardized, cross-location structure would certainly have resulted in fewer incomplete data sets in the intraindividual evaluation. Furthermore, the subjective self-evaluations were performed before and after each course module. As a result, the long-term success may have been overestimated since the gained knowledge had just been acquired. Evaluations completed with a time delay or for multiple modules could have further limited this factor. The objectiveness of the subjective self-evaluations assessed in this study could be increased in the future using surveys that include multiple modules and are completed with a time delay. In summary, due to its extensive experience with digitalization and networking, radiology was able to quickly provide a very good digital curriculum during the pandemic. The e-learning courses were well received and resulted in measurable learning gains.

Finally, it can be concluded that the German Radiological Society was able to offer German-speaking medical faculties important ad hoc support in the form of CoRad-19 so that excellent teaching could be maintained during the ongoing COVID-19 crisis. In addition, it should be noted that with these courses the German Radiological Society was able to increase student interest in radiology in spite of the pandemic.

Conflict of Interest

The authors declare that they have no conflict of interest.

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