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Long-term didactic innovations in higher education teaching caused by the coronavirus pandemic?

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During the coronavirus pandemic, many universities worldwide were closed and lecturers had to switch from face-to-face teaching to online distance education. Consequently, questions arose which routines in teaching the lecturers were able to use despite this change in teaching environments, and which didactic innovations they implemented in their courses. Lecturers' evaluation of these innovations and any aspects they intend to continue using after the pandemic and the return to face-to-face teaching were examined. Through a qualitative survey of 24 university lecturers in Germany and Panama, the long-term effects of the pandemic on teaching were investigated. It was found that the creation of new digital media for teaching, the use of new digital tools to ensure interaction and scientific exchange, the finding of new forms of organization, and combinations of synchronous and asynchronous teaching were all considered to be positive didactic innovations that should be maintained after the pandemic.

KEYWORDS

innovation, university teaching, COVID pandemic, survey of lecturers, Germany, Panama

1. Introduction

During the coronavirus pandemic, between March 2020 and spring 2022, lockdowns were imposed in the majority of countries globally, which led to university closures. Around 220 million students worldwide were affected by the disruption to university teaching caused by COVID (Farnell et al., 2021, p. 4). Lecturers were forced to offer their courses digitally with very little preparation time. This included digitizing teaching materials and uploading them to learning platforms, recording lectures and offering them digitally, and holding video conferences with students. Although the use of digital media in university teaching has been discussed for a number of years and a variety of e-learning approaches have been developed (Bates, 2005; Siemens and Downes, 2008; Anderson and Dron, 2011), not all lecturers were informed about the existing technical and didactic possibilities and most had little experience in using digital media in their teaching. As a result, during the coronavirus pandemic some lecturers felt overwhelmed (Sommer et al., 2021) and for many the enjoyment of teaching decreased (Schwab et al., 2022, among others).

Despite the adverse technical conditions (Figallo et al., 2020, Graell, 2021, Zalat et al., 2021, among others), surveyed students and lecturers from different countries also saw many advantages and potentials of the newly experienced digital teaching and learning formats. Students saw, for example, flexibility and autonomy in learning, as well as potential for digital competence development, as advantages of online teaching (Brunner 2021). In the lecturers

surveyed, the conservation of resources and room capacities, as well as increased flexibility, were also seen as positive outcomes of the situation (Hafer et al., 2021). Many lecturers also stated that they learned new skills during the pandemic (Zalat et al., 2021), which they want to continue to use after the pandemic (Benito et al., 2021).

While the perception of the new digital teaching and learning conditions during the pandemic by students and lecturers worldwide has been extensively documented (Cutri et al., 2020; Benito et al., 2021; Khan et al., 2022; Romero Oliva et al., 2022), the extent to which lecturers continue to use the innovations in online teaching after the pandemic have not been explored in detail. This question arises insofar as the innovations during the pandemic did not occur voluntarily, but are to be seen as the result of an external compulsion. In this context, there is talk of "Emergency Remote Teaching (ERT)" [Hodges et al. (2020) in Neuber and Göbel (2021)] or "Forced Online Distance Education" (Dolenc et al., 2021). Previous findings on innovations in school teaching show that teachers are very skeptical of innovations that they do not want themselves but are instead forced on them by the system (Krohmer and Budke, 2018). It could therefore be that after the removal of the compulsion to teach online, lecturers will return to their pre-pandemic teaching routines. However, it is also possible that the pandemic will lead to a long-term reform of university teaching. To fill the research gap in this topic, this article explores the following research questions:

1. To what extent could teaching routines from classroom teaching be maintained in distance teaching during the Corona pandemic?
2. What didactic innovations did university lecturers implement in their online teaching during the pandemic, and what are their reflections on these techniques?
3. To what extent do lecturers want to maintain or further develop the didactic innovations they made in their teaching after the pandemic?

To investigate the answer to these questions, 24 in-depth qualitative interviews were conducted with lecturers from Germany and Panama universities, which were subsequently analyzed by content analysis.

In the following article, the state of research on the impact of the pandemic on university teaching worldwide is presented. In addition, the concept of innovation is presented theoretically and related to university teaching. This is followed by a description of the methodical approach, the presentation of the empirical results and the discussion. Finally, the research questions are answered and consequences for future university teaching are considered.

2. State of the art

2.1. Impact of the corona pandemic on university teaching

A number of studies on the impact of the coronavirus pandemic on university teaching are available from different countries. These are usually based on qualitative or quantitative surveys of lecturers or students. The research found that a major problem was that technical problems occurred during the conversion to digital teaching, especially in countries in the global south, which relates to poor internet connections or a lack of technical equipment for students, and hindered the smooth progress of online teaching (Figallo et al., 2020; Graell, 2021; Abdi et al., 2021; Hastuti et al., 2021; Zalat et al., 2021; Pillaca-Medina et al., 2022, among others). However, the existing studies also reveal commonalities across countries, which are discussed below.

International data on this subject show that the short-term conversion from face-to-face teaching to digital teaching during the coronavirus pandemic in 2020–2022 was largely successful at universities worldwide. For example, 62% of the almost 30,000 international students surveyed by U-multirank stated that no courses were cancelled during the coronavirus pandemic (quoted from Berghoff et al., 2021, p. 11, U-multirank). With regard to Germany, a survey of 665 professors in the CHE ranking for the winter semester 20/21 showed that less than 5% of lectures, seminars and exercises were cancelled. However, similar figures are much higher for practical courses such as excursions in geography (43%) and laboratory practical (9.6%) in medicine (Berghoff et al., 2021, p. 9). 70% of the 27,000 students who took part in the CHE ranking survey rated their university's handling of the coronavirus pandemic as "very good" or "good," and only 2% of the students rated their university's handling of the coronavirus pandemic as very poor. The U-multirank survey of students at universities worldwide displayed similar values. 67% of respondents considered their university's handling of the pandemic as "very good" or "good" and only 3% rating it very poorly (U-multirank, 2021).

Other positive findings from surveys of students and lecturers worldwide, it can be noted showed that inclusivity, flexibility (Hafer et al., 2021; Neuber and Göbel, 2021; Romero Oliva et al., 2022) and the availability of recorded courses were considered to be positive (Khan et al., 2022). It was also perceived that one's own digital competences increased or could increase through digital teaching (Benito et al., 2021; Neuber and Göbel, 2021; Zalat et al., 2021). Lecturers also reported that they implemented pedagogical innovations in their teaching during this time (Neuber and Göbel, 2021, p. 64).

In contrast, some negative effects of online teaching were also reported by interviewed lecturers and students. The key points identified were the lack of interaction, reduced academic exchange, and low social contacts between lecturers and students and between students (Berghoff et al., 2021; Hafer et al., 2021; Neuber and Göbel, 2021; Sommer et al., 2021; Khan et al., 2022; Pillaca-Medina et al., 2022). In the study by Hafer et al. (2021, p. 95), interviewed lecturers stated that they found it particularly difficult to reach less qualified students when teaching digitally. In addition, learner orientation seems to be more difficult for lecturers to implement in digital teaching (Gómez-Hurtado et al., 2020). In the survey by Benito et al. (2021), lecturers stated that they are not always sure whether students are really listening and that it is difficult to motivate students in video conferences. Lecturers also noted an increased workload (Neuber and Göbel, 2021, p. 65).

Students reported that they felt they learnt less through digital teaching than in face-to-face teaching (Benito et al., 2021). "Nearly half of students believed that their academic performance has declined since the end of face-to-face courses, and more than half of the students surveyed reported that they suffer from a heavier workload since the transition to online teaching" (Farnell et al., 2021, p. 5). The

U-multirank survey, which surveyed 30,000 international students, found that students were more negative about their learning situation in 2021 compared to 2018 (before the pandemic) (U-mulitrank, 2021). Peruvian students interviewed were particularly critical of the quality of practical courses and professional training during the pandemic (Pillaca-Medina et al. 2022).

The majority of existing studies have manly examined the status quo of teaching and its perception during the pandemic. Some studies have gone beyond this and asked lecturers about their visions for teaching in the future. In these studies the vast majority of lecturers surveyed stated that their teaching would benefit from the experiences of the pandemic period (Benito et al., 2021). Meishar-Tal and Levenberg (2021) found that perceptions of professional success in adapting teaching to the conditions of the pandemic had a major impact on lecturers' intentions to continue to teach synchronous digital courses in the future. The teachers interviewed by Hafer et al. (2021) assumed that there would be a return to normal face-to-face teaching after the pandemic. However, they were convinced that the use of digital solutions would play a major role in post-pandemic teaching. Of the 662 lecturers surveyed in the CHE ranking, 18% said they wanted to return to pure face-to-face teaching after the pandemic, 39% want to do face-to-face teaching enriched with digital elements, and 36% aspire to blended learning. Very few lectures surveyed want to implement hybrid teaching (5%) or pure online teaching (2%) in the future (Berghoff et al., 2021, p. 28).

There is some evidence in these studies that learning environments in universities worldwide will change as a result of the digitalization push in the context of the pandemic (e.g., Ramírez-Montoya, 2020), but so far no research has been undertaken on how lecturers' experiences and the didactic innovations created during the period of forced online teaching will affect teaching after the pandemic. For this reason, this is the focus of this article. In order to explain the theoretical framework, the following section outlines with what didactic innovations are.

2.2. Innovations in teaching

Innovations are often equated with novelties, which also corresponds to the Latin origin of the word "innovatio" (something newly created). However, there is no universal definition of the term innovation in scientific literature (Reinmann-Rothmeier, 2003). Many authors have emphasized that the development of new ideas is not yet an innovation (e.g., Behrends, 2001, p. 97; Luchte 2005, p. 18ff). Only the implementation, use and acceptance of these ideas for changing processes, products and technologies leads to innovations. Older definitions see innovations as fundamental and radical changes that primarily originate from experts (Bullinger, 1994), whereas newer definitions tend to emphasize the process character of innovations and the fact that they must be new, accepted and implemented for the respective area (e.g., Anderson et al., 2004, p. 148).

Goldenbaum (2013, p. 151) distinguishes between different levels (macro-, meso-, and microlevel) at which innovation in the school education system can occur. Similarly, if we look at innovations in higher education teaching, we can distinguish between different levels at which they are located (see Figure 1). At the macro level, educational policy and laws determine the structure of higher education, the technical and financial resources, and the strategic orientation of higher education institutions (Brennan et al., 2014). At the meso level, university administrations and faculties act, influencing, among other things, the orientation and organization of study programs and research, strategically distributing technical and financial resources and organizing continuing education. At the micro level, teachers are among the key actors in influencing the learning success of students (Helmke, 2012, p. 109). There are several studies which have shown that teachers are of great importance in the process of implementing reforms and for innovation in a school context (Döbert, 2003; Borko, 2004). University lecturers have a similarly high level of importance in the development and implementation of innovations in university teaching, where they contribute to the development of the curricular, define teaching goals, determine course types and didactic settings, and select didactic methods and media in relation to their respective learning groups.

These micro-level innovations can also be called didactic innovations. "Didactic innovations are innovations in the organization, content and/or methods of teaching that noticeably change the previous state of knowledge transfer and, as a consequence, also bring about a change in the intended educational and learning processes" (self-translated from: Reinmann-Rothmeier, 2003, p. 11). This type of innovation is the focus of this article, in which university lecturers are asked about their didactic innovations during the Coronavirus pandemic and resulting long-term innovations. For new didactic actions to be transformed into innovations, it is necessary that they become established, are carried out repeatedly and thus become routines.

2.3. Didactic innovations and routines

University teaching can be understood as social interactions that are carried out repeatedly and routinely. The completion of the innovation is achieved when a didactic innovation, such as conducting group work during video conferences, has proven successful in the context of teaching and learning and is therefore used repeatedly. The innovation has then been turned into a new routine (Reinmann-Rothmeier, 2003, p. 9). The connection between routines and innovations can also be found in the following definition of innovations, which are applicable to education: "Innovations in (geography) classes are deemed to be alterations that lead to a break with routines and are accepted and recognized by the respective social environment (teachers, students). The changes can consist of new combinations of known elements and thematic contexts, and do not have to be fundamentally new. They should be repeatable as well as convertible into new routines" (Krohmer and Budke, 2018, p. 421).

As Figure 2 shows, and as Krohmer and Budke (2018) and Krohmer and Budke (2021) also highlighted, routines and innovations are interrelated. Routines in typical action situations of university teaching can be broken by innovations. If they are seen as successful and accepted, these can become innovations that change teaching in the long term. Through repeated use, the innovations can then become new routines. Routines are thus both a prerequisite and a consequence of innovations. In this context, it is important to understand that routines are actions that are used in recurring decision-making situations and that serve to reduce cognitive stress, and to quickly make automated decisions that have already been successful in previous situations that can be used in similar new

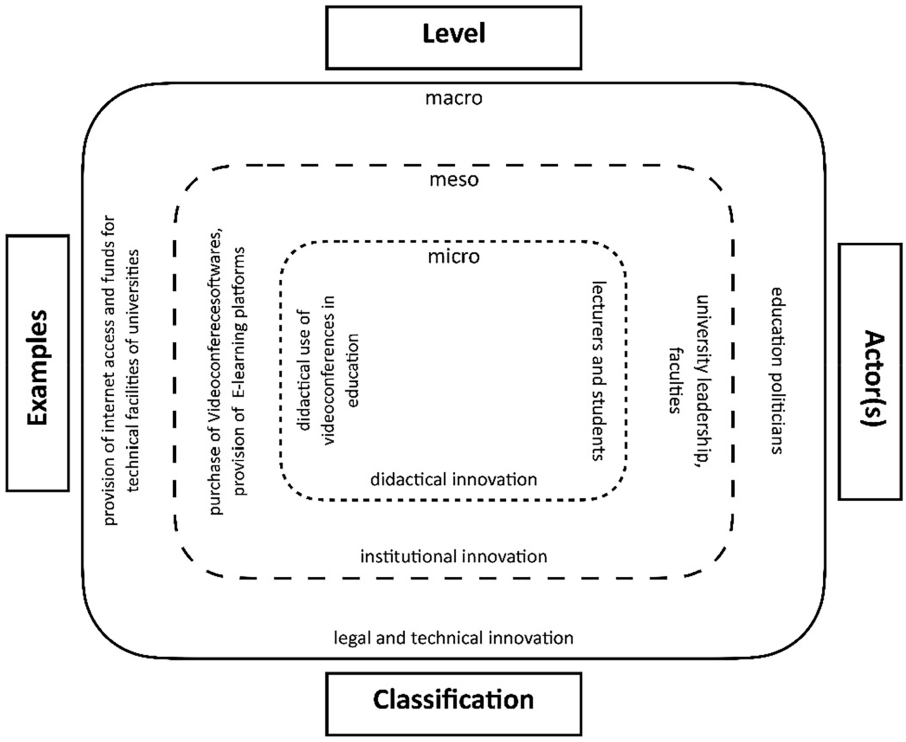

FIGURE 1
Levels, types and actors of innovations in higher education teaching (adapted from Krohmer and Budke, 2018, p. 420).

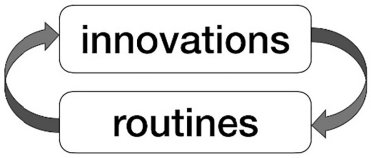

FIGURE 2
Interrelationship between routines and innovations (own illustration).

situations (Betsch et al., 2002). "Humans process and respond to complex tasks on several levels. The foundation is formed by a system of routines (i.e., practical behaviors) which are enacted as soon as the relevant stimulus conditions are perceived" (Bromme and Brophy, 1986, p. 108).

Routines can be acquired through one-trial learning and also include habits acquired through learning in repeated situations (James, 1890). Routines play a major role in teaching at school and university (Krohmer and Budke, 2021). This can be explained by the fact that these routines relieve teachers in the evaluation of concrete teaching situations, they are based on the subjective theories of the teachers (Linsner, 2012), their understanding of the subject (Kanwischer et al., 2004), professional knowledge and concepts of teaching, and their own biographical experiences as students. As didactic routines have an important function for experienced teachers, didactic settings, as well as typical teacher-student interactions, among others, will change very slowly. Universities have therefore been characterized by a high degree of consistency over centuries (Deimann, 2021, p. 26).

The next question to arise is to what leads to routines being abandoned, new things being tried by teachers, and innovations being established and transferred into long-term new routines.

2.4. Innovation triggers

Triggers of innovation can theoretically be located at all levels of the model in Figure 1. From the point of view of the teachers interviewed, impetus for innovation on the meso- and macro level are often seen as external requirements that they are supposed to implement in their own teaching, which they sometimes do reluctantly. On the other hand, they locate "internal" innovation impulses on the micro level. These are implemented if established routines are no longer seen as successful for teaching (Krohmer and Budke, 2018).

The literature review conducted by Baharuddin et al. (2019, p. 215) revealed, in relation to innovative work behavior of school teachers, that the following factors have an influence on the part of teachers, as various studies show: work engagement; job control; openness; motivation; job satisfaction and; interaction within the job, job autonomy and job commitment. Krohmer (2021) also highlighted that the ability of teachers to reflect is crucial in order to identify the value of routines and innovations. Moreover, teachers must be dissatisfied with existing routines in order to have the motivation to change them. If teachers are very satisfied with their didactic routines, it will be difficult to change these routines (Schlöglmann, 2005, p. 156 ff). It can be assumed that factors that influence innovations at school by teachers are also relevant for didactic innovations at university.

If one relates what has been said about the coronavirus pandemic and the question of whether it will produce long-term innovations in university teaching, the forced conversion of classroom teaching in distance teaching must be seen as an impulse for innovation that was triggered by education policy-makers at the macro level (see Figure 1).

3. Methodology

In the following section, the methodological approach of this qualitative study and how it answers the research questions is presented.

3.1. Participants

Data collection was based on the use of theoretical sampling, which aimed to explore varied ranges and conditions, and thus contemplate the greatest number of scenarios throughout the study (Glaser and Strauss, 2017). Therefore, lecturers from completely different university systems in Germany and Panama were selected, belonging to the global North and South and therefore expected to have very different perspectives. The interviewees were as diverse as possible, differing in age, gender, professional experience, discipline, and the country in which they teach. The lecturers approached from both study universities were from different faculties within the universities, had varying levels of experience and different characteristics. The lecturers to be selected also needed to teach classes before and after the pandemic. A total of 24 lecturers, of whom 11 were from the University of Cologne Germany and 1 from the University of applied science in Cologne, and 12 from the Technological University of Panama were interviewed using guided interviews. At the University of Cologne, lectures from the Faculty of Mathematics and Natural Sciences participated. At the Technological University of Panama, lectures from the faculties of Science and Technology, Civil Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering and Computer Systems Engineering were interviewed.

Table 1 shows the total number of lecturers who participated in the research.

All participating German lectures work as research staff or lecturers at the University of Cologne. As an additional comparison case, a research assistant at the Technical University of Cologne was interviewed. All German interviewees have teaching and research responsibilities. The weekly teaching loads of the interviewees ranged from two to 16 h per week during the semester. Some of the respondents mainly taught practical courses and seminars with 10–30 participants, whilst others also taught lectures with 100–300 participants. The years of teaching experience for the German group ranged from 3 to 35 years. The interviewees age range between 30 and 65 years. Most of the Panamanian interviewees' main responsibility was to teach, with three of 12 also having research responsibilities. The years of teaching experience of the Panamanian group ranged between 11 and 30 years, and the age between 29 and 59 years. The majority of the interviewees taught groups of 60 and 150 students during the semester. There were two interviewees from the group with previous experience in e-Learning.

3.2. Data collection

Research questions were created at the beginning of the study to identify the routines in the respondents' teaching, their innovations during distance teaching at Corona time and their long-term plans to use these (see research questions in the introduction). Based on these research questions, an interview manual was designed as a data collection instrument. The structure and design of the interview was based on a structured interview type (Hernández-Sampieri and Mendoza, 2020). A manual was prepared as shown in Table 2, and the same set of questions was asked to all participants although the order was varied according to the course of the interview. Based on our theoretical model (see Figure 1) and the literature presented in chapter 2, questions were asked about routines before the pandemic and innovations during the pandemic (questions 1 and 7 in Table 2). Since previous studies have shown that the evaluation of innovations by those involved is decisive for whether they are retained in the long term and become innovations (Schlögmann, 2005), the lecturers were asked about their evaluation of the innovations during the pandemic (questions 2–6 in Table 2). These first seven questions served to answer research questions 1 and 2. The third research question about long-term didactic innovations after the end of the pandemic was investigated through interview questions 8–10 in Table 2.

The interviews were undertaken using the Zoom or Microsoft Teams software and the audio was recorded. The interviews lasted between 30 min and 1 h and were conducted in Spanish and German. All lecturers agreed to the interviews, which can also be seen from the fact that they actively dialled into the video conference we used for the interviews. There we explained the study again, explained the topic and addressed the goal of recording audio data, transcribing it and analyzing it scientifically. Then we activated the audio recording, to which all participants actively agreed. When analyzing the data, they were anonymized. The survey period was between February and April 2022.

3.3. Data evaluation

The evaluation was carried out by means of a qualitative content analysis (Mayring, 2004). The central part of the analysis was based on categories, which originated from the research questions. The categories created deductively on the basis of the model used (see

TABLE 1 Participating lecturers.

University	Participating lecturers		Total
	Men	Women	
University of Cologne (11), Technical University of applied science (1) in Germany	10	2	12
Technological University of Panama	4	8	12
Total	14	10	24

TABLE 2 Interview manual.

#	Questions
1	What teaching routines that you had in place before the pandemic have changed due to COVID-19 conditions?
2	What changes made to your courses were positive in terms of: learning impact and transfer of skills to students?
3	What advantages did you perceive in relation to the courses you taught during the pandemic compared to the courses you taught before the pandemic?
4	What changes were negative?
5	How did you address these problems, and what were your approaches to resolving them?
6	Which of your approaches were successful?
7	Which of the approaches that you considered successful did you use repeatedly during the COVID-19 period?
8	What long-term changes do you expect for teaching in the future as a result of COVID-19?
9	Which of the changes in your teaching during the pandemic will continue after the pandemic? And your reasons for this.
10	How do you value blended (digital and face-to-face) teaching formats? Where do you see potential and difficulties?

TABLE 3 Categories for content analysis.

ID	Category	Description	Citation
1	Teaching routines	Actions in learning that were routinely performed before and during the pandemic.	Prior to pandemic, it was customary for students to make presentations and then discuss them together. Consultation hours were in the office of the corresponding professor (GE_f1).
2	Pandemic-induced changes in teaching routines	Changes in: Organization, student outcomes, student understanding of the subject, student interaction and lecturer role.	The exams were online, so monitoring students and making sure they were not using unauthorized aids was very difficult and was done in part by proctoring on Zoom (GE_m7).
3	Evaluation of changes	Evaluation of positive and negative changes in teaching during the pandemic.	Much more difficult to activate online students. There are few who participate. I have the feeling that students are quieter, more withdrawn and you must push them harder to get them to say something (GE_m6).
4	Expected future changes in education	Changes envisioned by the lecturer of teaching in the future as a result of online teaching during the pandemic.	To make mixed programs, so as not to say 100% virtual, suddenly the first years are face-to-face and the last years are distance learning, and that gives the students a lot of flexibility at the time, because in the last years the students enter the labor field and it can be very beneficial for them (PA_m8).
5	Relevance of the COVID-19 experience for future education	Lessons learned during the pandemic for future experiences.	We need to be a little more empathetic. Put yourself in other people's shoes; not all of us are under the same condition, comforts to study (PA_m4).
6	Evaluation of hybrid learning	Perception of the combined use of face-to-face and distance modality in teaching.	Perhaps, establish days that are always digital and days that are always face-to-face. I think that would also make it easier for students to build their schedule this way (GE_f1).
7	Long-term application of innovations	Applied strategies that will continue to be used and the institutional framework conditions for their continuity.	Inverted class is a good long-term strategy, but I think it should not be the only one. We should see which strategies are the best (PA_m2).
8	Wishes for the future in relation to education.	Aspirations in future education.	I would like that, at the institutional level, they implement programs, if not virtual, at least mixed. With a well-organized schedule where days that are distance learning and days that are face-to-face are defined (PA_m8).

Figure 1) are suitable for answering the research questions. Category 1 in Table 3 comprises interview statements on didactic routines before the pandemic and was formed to answer research question 1. Categories 2 and 3 include interview statements on didactic innovations during the pandemic and their evaluation and serve to answer research question 2. Categories 4 to 8 refer to the interviewees' wishes, assessments and plans for the further development and retention of innovations from the pandemic after its end and thus serve to answer research question 3.

Rules of analysis and data validation criteria were also applied. Identification of the validation criteria included a procedure that seeks to measure the level of agreement between evaluators in the categories and to check the reliability of the data analyzed. Finally, an interpretation of the results was made (Mayring, 2004).

For the purpose of this study, eight categories have been defined and are presented in Table 3.

The interviews were conducted and transcribed. The information obtained was analyzed and categorized using QCAmap, a content analysis tool. The degree of congruence of the different researchers in categorization were validated by means of Cohen's Kappa Coefficient, obtaining a substantial agreement with a coefficient of 0.78 in the University of Cologne Germany with regard to the German interviews

and in the Technological University of Panama, initially a coefficient of 0.45 being a moderate agreement was achieved. Subsequently, the evaluators discussed the categories again and re-evaluate the contents. Ultimately a coefficient of 0.99 was achieved.

The results for each category in both countries are summarized separately and then compared. In this way, both differences and similarities in the data collected between the two universities are identified.

All participants agreed to the interviews, which can also be seen from the fact that they actively dialled into the video conference we used for the interviews. There we explained the topic and addressed the goal of recording audio data, transcribing it and analyzing it scientifically. Then we activated the audio recording in Zoom or Microsoft Teams, to which all participants agreed actively. The data were then anonymized and analyzed.

4. Results

In the following, section the results of the research are presented. They are sorted in such a way that they answer the research questions one after the other. First, the teaching routines from classroom teaching retained by the respondents during distance teaching during the Corona pandemic are presented (research question 1). Then the didactic innovations implemented by university lecturers in their online teaching during the pandemic are presented (research question 2). Finally the results of the third question are presented, which investigates to what extent lecturers want to maintain or further develop the didactic innovations they made in their teaching after the pandemic.

4.1. Didactic routines in university teaching that were maintained during distance teaching in the coronavirus pandemic

Prior to the pandemic, teaching was entirely face-to-face for the German participants and predominantly face-to-face for the Panamanian participants. Copies and analogue books were used, as well as some digital tools within the course (especially presentation slides) and e-learning platforms for course preparation and follow-up. *"Yes, before the pandemic I actually only used classic PowerPoints* etc.[1]*" (GE_m1).* The types of teaching included lectures, seminars with group work, tutorials, practical courses and excursions/ field work. In some cases, there was a high level of practical application, for example the courses that took place in the teacher training programme in cooperation with schools. Many of the German lecturers had students prepare and hold parts of the seminars, and spontaneously led discussion and reflection phases. On the other hand, in the Panamanian university, the pre-pandemic courses were not planned alongside students. The Panamanian teaching was usually a combination of lectures (knowledge presentation by the lecturer), questions to the students and exercises. Students' comprehension problems were spontaneously addressed in the courses and explanations were given in the presence of the students: *"Being able to develop a class on the board and not have it recorded, that is, if the student did not assimilate a concept at the time it was explained or for some reason could not attend the classroom that day, he/she would lose that explanation."* (*PA_f11*). Generally, classes in both universities were not recorded, which meant that the students had to be physically present. It was customary for students in both countries to give presentations and subsequently discuss them in the class. Consultation hours were also held in the offices of the respective lecturers.

During the pandemic, according to the interviewees, only analogue or synchronous distance learning was practiced. Despite these drastic changes, the interviewees reported many routines that they were able to maintain in teaching. For example, the lecturers tried to teach the same content as before the pandemic. *"So, in terms of content, there were hardly any changes" (GE_m2).* At both universities, similar social forms and methods were used during the synchronous digital courses as in face-to-face teaching, including lectures, discussions and presentations, and group work in break-out rooms: *"But of course we could also use other methods that usually work, such as group puzzles*[2]*, which you can actually do online. We did that with different break-out rooms. So that worked well."* (GE_m3). In addition, project work continued to be undertaken: "*When it came to developing the project, they simulated, they joined together, 3 students in each group and they joined together, they put together their project and they presented it, they were all creative and the truth is that I was very happy for them, because the virtuality was not a constraint to develop their projects" (PA_f12).* The preparation of the courses together with students, as well as the moderation by these courses and subsequent reflection, which was common for the German lecturers before the pandemic, was also maintained with the help of digital consultations and synchronous, digital courses: *"So by the fact that even in the pandemic the students still chaired the session, we also always of course reflected on the session" (GE_f1).* With regard to purely asynchronous courses in Germany, these were mainly used for lectures in the coronavirus period. Here, presentation slides that were shown in person before the pandemic were provided during distance teaching with explanations and digitally recorded: *"Basically asynchronous, so discussed slides. Essentially, I added audio comments to my PowerPoint slides"* (GE_m3). Likewise, students were expected to record their presentations and make them available digitally.

4.2. Didactic innovations developed during the coronavirus pandemic and their evaluation by lecturers

4.2.1. New digital tools to ensure interaction and scientific exchange

The fact that the interaction between students, and between students and lecturers, reduced was one of the greatest challenges of synchronous distance teaching, which was explained in detail by lecturers from both

1 All quotations found below have been translated from German or Spanish.

2 Group puzzle is a method in which topics are worked out in groups in a first phase. In a second phase, the groups are mixed so that there is one representative from each of the original groups. These experts then report to each other on their findings in the first phase.

countries: "*Interaction with students was lost during the pandemic. That was replaced by chat rooms, forums, e-mails" (PA_m3).*

"It was actually the case that they (students) were very, very passive, especially in seminars where you actually want to have discussions" (GE_m5).

The interviewees reported that many students did not actively participate in the courses and it was difficult for the lecturers to assess whether the students were present at all. In some cases, lecturers suspected that the virtual and anonymous environment of videoconferencing intimidated students and they therefore did not speak up, or they suspected that they were less focused due to domestic distractions. Lecturers lacked non-verbal communication in virtual courses and found it more difficult to guide interaction than in face-to-face courses. Many lecturers addressed this problem with their students and tried to find solutions together. "*And then we always reflected together: what can be changed for the next session so that participation is perhaps more extensive?"* (GE_f1).

Lecturers from both countries report that previous teaching routines aimed at active student participation, such as asking questions and engaging students to initiate academic exchange in the course, were used with little success during synchronous distance teaching. To counteract this problem, the lecturers used group work in breakout sessions and tried a number of digital programs that were new to them in order to motivate and activate the students, and ensure a scientific exchange. *"The main goal was to somehow overcome the distance through cooperative forms of work"* (GE_m1). Lecturers tried various digital tools to get feedback on their course and the learning process of the students. They used tools such as quizzes, games, Open Educational Resources (OER), software for presentation, project development and collaborative programming, and software for feedback and voting.

The lecturers consistently described the conversion of face-to-face teaching to digital teaching as a challenge that has led to their own didactic development, and a greater knowledge of a wide range of digital programs that can be usefully employed in teaching. *"But one has also become much more self-confident and competent with these tools and uses them quite naturally" (GE_m6).* In addition, the lecturers noted that they worked more intensively, through a greater number of e-mails, as well as using the chat function of the video conferences and digital consultations, to ensure the exchange with the students.

4.2.2. New forms of organization and combinations of synchronous and asynchronous teaching

It became apparent that the routine of face-to-face teaching, in which teaching was at fixed times in 90 min[3] blocks, was too long for synchronous digital courses and the students' attention could not be held for that long: *"So this, "please, please do not make us sit in front of the screen for 90 min. That's super exhausting!" and I always find that exhausting as well myself"* (GE_f2). Lecturers in both countries observed fatigue when students had a number of video conferences in a row, and therefore lecturers switched to shorter synchronous digital courses, were very flexible in their scheduling, and shifted content to tutorials or asynchronous teaching sessions. The lecturers interviewed tried a wide variety of combinations of synchronous and asynchronous courses during the pandemic. Since asynchronous courses increased in importance, much more often than during the teaching before coronavirus, work was done with material provided for the preparation and follow-up of the video conferences, as well as suitable exercises and tasks, which the students had to work on at home and submit via the e-learning platforms used in the universities. The lecturers then provided written or oral feedback on these exercises during the synchronous courses with video conferencing. *"In cartography, I have made blocks. Every three sessions, we meet in Zoom and discuss the problems that have come up until then and I also bring a few tasks that are discussed live" (GE_m4).* Another reason for the increased use of exercises in all German courses and in the courses with a practical component in Panama, which had to be worked on by the students at home and handed in to the lecturers, was that many lecturers found it difficult to gauge students' success in learning and understanding process during the video conferences, particularly when students were not visible on the video calls and many did not say anything. In addition, lecturers indicated that interaction with students was one of the most difficult aspects: "*What I found most difficult was to maintain interaction with the students, because when you are in person with them, I could see them and identify some gestures that indicate that there is some doubt or question, which is not possible with these distance education tools" (PA_f5).*

The increased use of digital exercise material and tasks is largely viewed positively by the lecturers, as this supports individual learning success. *"For me it was positive that these feedbacks were actually more individual. Through this weekly homework"* (GE_m3.). Many interviewees reported a high level of student engagement in working on the exercises. However, giving individual feedback was often a challenge as it was very time-consuming for the lecturers.

4.2.3. Creation of innovative media for teaching to increase student motivation and self-organization

In order to increase the students' motivation when working on asynchronous digital course units, some lecturers took the opportunity to revise their previous teaching material and design it to be more stimulating. *"As a lecturer, I have had to reinvent myself, I have concentrated on creating the modules in the most detailed way possible, accompanying them with videos. I have to make the modules colorful and attractive to them. The issue of motivation is very important to achieve this effect on the students." (PA_f9).* Another lecturer explained that he focused on video development: "*I started creating videos for the students, uploading them to a YouTube channel and then I created a video for each problem*" (*PA_f11*).

Lecturers in both countries also reported that innovative teaching materials were developed together with students. In some cases, automated feedback was used within the self-created materials (e.g., close text or assignment tasks) and in some cases short tests were written after the materials had been studied in order to give the students feedback on their learning success and to check whether the student had really been worked on the materials.

As access to libraries and printed books were limited in both countries during the pandemic, digital media available via the Internet were used much more in teaching than before the pandemic. "*I have a course called construction methods and costs, through this use of the Internet we could access live pages where contractor selection procedures were being given, current files that were valid at the time, current events*" (*PA_f5*). The use of a wide variety of internet sources, which varied greatly in quality, resulted in the need to train the students in information skills to evaluate these media, as this lecturer stated: *"That*

3 In Germany, the courses before the pandemic were usually 90 min long. At the Panamanian university, a course was 45min. However, two 45 min units were also often given consecutively, so a learning unit was also 90 min.

they learn to distinguish between what information is useful and true and what is not real, because in a couple of seconds they have access to 1,000 files, but not all of those documents are true. Basically, it's guiding them and making sure that what they are learning is in fact related to their professional practice and their professional competence" (PA_f5).

Some lecturers found the use of digital learning media and lectures set to audio with explanations positive as it enabled students to learn at their own pace and set their own priorities. Consequently, they saw the potential of digital and open educational media if they were of high quality. According to the lecturers, working with innovative media that students have to work out individually trains the students in self-responsibility and ability to organize themselves.

"Yes, I completely videotaped my lectures and then put them online. Which had the advantage for the students, as I've heard, that they could then learn very independently, listen to and watch them as often as they wanted, find their own rhythm. That was very positive." (GE_m7). However, it was also noted that the students' ability to organize themselves varied, and that the quality of work varied greatly between students. *"The rhythm was not the same, it was rather unbalanced: some went further, others less far, some were too far behind. So when all the content was made available, those who had the ability to learn a subject studied it on their own. When I got to teach that subject area, that student was quite advanced" (PA_m8).*

Sole provision of innovative teaching material without further integration into synchronous (face-to-face) courses was viewed critically by many of respondents, as the success of learning by this method was questioned. "*If one understands learning as a social process, and I do, then it is quite clear that communication and social contact were of course prevented here, and politically I also find it unacceptable that the students were forgotten for so long, and for years they had to learn alone in a private room, and that is not how learning works. They have to exchange ideas, they have to meet, they have to discuss*" (GE_m2). In addition, the lecturers complained that the creation of high-quality, digital materials for university teaching was extremely time-consuming.

4.2.4. Substitution of practical courses

Lecturers who had taught courses with a large practical component were faced with the problem of having to replace this practical part when the coronavirus pandemic caused teaching to go online. For example, instead of practicing teaching in the teacher training program with a school class, the lecturers gave students the task of creating didactic teaching material such as explanatory videos: *"Yes, so in the "Principles of Subject Didactics"" and also in "Subject Didactics One" "I actually always made sure that we somehow got into the school and that was then not possible, or very difficult to do, and then I let them design, for example, explanatory videos on small thematic units from geography lessons" (GE_m8).*

Excursions were replaced, for example, by the development of digital excursions by students, which the students then exchanged and tried out. Conducting experiments was more difficult. *"That was done in a different form. Then just one person did it and went into the kitchen and did the experiments on behalf of the others in the group" (GE_m2).* At the University of Panama, laboratory courses in the natural sciences or courses on programming and robotics were affected. Digital simulations were used in these courses. However, there were not simulations for everything and some of them had to be paid for. Although the interviewees described many creative ways in which they had tried to maintain the practical nature of their courses despite the distance teaching, they still evaluated the solutions they had found more negatively than their practical courses before the pandemic, such as the following lecturer who held practical courses in schools for student teachers before the pandemic and found that these could not be replaced digitally: *"The best thing would have been for them to go to school, because of course you learn about face-to-face teaching, when you do face-to-face teaching. In theory, of course, they have learned something, but in practice they have learned less" (GE_m2).*

4.3. Didactic innovations from the coronavirus pandemic that university lecturers want to maintain or modify in the long term

Due to the lack of social and academic exchange experienced by lecturers from both countries, many wanted a return to face-to-face teaching after the end of the pandemic: *"But I think that overall it is very, very important to have these courses again, where you can really exchange more, and I think that can be achieved much better in face-to-face teaching"* (GE_m5). However, didactic innovations from the coronavirus period were also mentioned, which the lecturers wanted to maintain in the long term.

4.3.1. Digitally supported face-to-face teaching

Lecturers in both countries had said that they were able to greatly expand their knowledge during distance teaching using the digital programs currently available. Since this was experienced as a positive expansion of competence and a number of advantages and potentials of these programs were noted, such as visualizing work results, giving feedback or structuring group processes, many respondents concluded that they would like to use such digital programs in their future teaching "*Face-to-face classes are not going to be the same as they were before, I think I am, I can say that I am 100% sure, that most teachers are going to use a platform, whether it is Teams, whether it is Moodle, whether it is Chamilo, whether it is any other or even using a cloud, to use it as a repository or to receive some kind of homework" (PA_m8).* Many respondents from both countries formulated an ideal for digitally supported classroom teaching: *"In my experience, nothing can be done without classroom teaching (...). But my thought would be to work on how I can make better use of the attendance time. I'm really thinking about things like using and integrating the whiteboard better. (…) Or that the students can actually work on exercises on their tablet or smartphone. But everything really on site" (GE_m3).* Many respondents made similar assumptions that in the future all students will bring their own digital devices to the university, so that certain tasks such as internet research, preparing presentations or creating their own digital media using a wide range of programs will be possible without problems. A need to create additional workspaces for students, to provide internet and charging facilities for all, was also proposed.

4.3.2. Flexible forms of organization of face-to-face teaching synchronous and asynchronous distance learning

Many lecturers wanted to maintain the flexibility they have experienced within the organizational forms of synchronous and asynchronous distance learning in future, and integrate it into classroom teaching. Some of the lecturers no longer want to have weekly face-to-face meetings, as they did before the pandemic, but want

to have face-to-face teaching at longer intervals, with synchronous or asynchronous distance teaching in between. This is justified by the perceived advantages of distance teaching, but also by the greater convenience for lecturers and students, and the better possibility of combining it with part-time jobs: *"But I believe that a large number of students work part-time and have to finance themselves on the side in order to allow a little more flexibility. You really have to say, "OK, where does it make sense to meet locally? Does it make sense to do this weekly?" (GE_f3)*. In the future, lecturers from both countries wanted to look for new ways to combine the advantages of face-to-face teaching with those of distance teaching: *"And this mixed combination of virtual and classroom-based learning I think we feel that it has a great advantage and that it should be continued in the future, even if we continue to be on-site, we should not loose this virtual part that we can exploit in some form so that students can interact outside of the classroom and continue to be more engaged in studying" (PA_f2).* Lecturers saw the advantages of synchronous distance learning. The lecturers all wanted to retain the possibility of video conferencing and wanted to use it primarily for their consultations and to supervise student group work.

The concept of flipped classrooms is mentioned as a possible combination of in person and digital teaching. Many lecturers had experienced the possibilities of digital asynchronous teaching using exercises, tasks and interesting materials and could imagine using this teaching method as a supplement to face-to-face teaching, and continue to offer part of their teaching, which is primarily about the theoretical development of concepts, approaches and theories, asynchronously. According to the opinion of many respondents from both countries, the face-to-face courses would then be used primarily for exchange and collaborative work. *"We use a didactic guide and tutorials. That's what we try to implement the most, give them a material for them to study, and then meet to discuss it (PA_f2)*. However, some interviewees wanted to use asynchronous distance learning not only to prepare for face-to-face sessions, but also to follow-up on them: *"The strategy that I would look for is the way to share information in order to ensure that the students have the possibility to get the information after class in order to read it and to review it" (PA_f4)*. Asynchronous digital course components are seen as particularly suitable for students who have difficulties getting to the university, for example, because they are doing an internship or live far away. Some lecturers in both countries mentioned that they considered the asynchronous course components to be suitable primarily for students in the later semesters of their degree who have already learned skills in self-organization and independent learning, rather than for students at the beginning of their studies.

4.3.3. Maintaining and further developing innovative teaching materials

Many respondents in both countries were been able to develop their skills in producing quality teaching materials during the coronavirus pandemic and wanted to continue to use them in the future. They particularly wanted to continue to develop materials for asynchronous digital teaching, and saw potential in the use of high-quality learning units and open educational resources (OER). *"So maybe you do asynchronous things. Teaching videos, for example, or open educational resources such as self-learning units and things like that. I think they could still be increased, because they are actually very interesting and good materials that offer great material and great possibilities in combination with courses" (GE_m5).*

According to the lecturers, the newly created materials not only support the learning success of the students but are also suitable for repeated use in subsequent semesters. *"I feel that the creation of videos is very positive, because not only it helped me to develop this course the first time I implemented it, but I can continue to use them to solve the same problems" (PA_f1).* To provide the materials, the lecturers want to continue using the e-learning platforms in their universities, which have been particularly effective during the coronavirus pandemic.

4.3.4. Strengthening practical components in the degree program

During the pandemic, the lecturers surveyed stated that they had tried a variety of digital options to replace the practical components of the degree program, such as laboratory work in the natural sciences, school projects in teacher training or excursions in geography. Since these didactic innovations were judged negatively by the respondents and they rated the learning outcomes on the students as significantly lower than in the practical courses before the coronavirus pandemic, the majority of them want to return to the pre-coronavirus status in this area or even further expand on the practical components in the degree program: *"I'm such an outdoorsy type, aren't I? Well, I would like to see (...) a stronger countermovement and going outside. (...) That you offer the opposite of digital. And that is my greatest wish. I also notice that among the students. They always find excursions great" (GE_m9).*

5. Discussion

This qualitative study has focused on the didactic innovations that university lecturers in Germany and Panama implemented during the forced distance teaching during the coronavirus pandemic. As this was a small study the results cannot be generalized in a quantitative sense. It is also not possible to say how many lecturers implemented innovations and in what way. However, it highlights how the coronavirus pandemic provoked innovations in higher education.

In order to answer the research questions "To what extent could teaching routines from classroom teaching be maintained in distance teaching during the Corona pandemic?" und "What didactic innovations did university lecturers implement in their online teaching during the pandemic, and what are their reflections on these techniques?" a theoretical model was used that relates routines and innovations (see Figure 2). The interrelationship between routines and innovations described in theory (Reinmann-Rothmeier, 2003) is clearly recognizable in the empirical data (see Figure 2). Lecturers in both countries surveyed reflected on their innovations during the coronavirus period compared to their teaching routines before the pandemic, evaluating them and considering how to derive possible new routines for the future. They had found that some routines from the time before the pandemic could easily be continued, such as the joint planning and preliminary discussion of courses with students at the German university, the implementation of certain didactic methods or the formulation of assignments and exercises.

However, the starting point for the innovations during forced distance teaching was that certain routines, such as the use of paper books as sources of information, the spontaneous control of interaction processes and academic discussions during classes, assessing the students' understanding and learning process by studying their facial expressions and gestures, carrying out practical work, e.g., in laboratories, as well as the standard organization of learning units in 90 min blocks, were no longer successful from their point of view. At first, they tried to maintain their teaching routines from before the

coronavirus period and then noticed that the interaction between students and lecturers decreased, they could not assess the learning outcomes, many students seemed unreachable, exhausted and passive, and that many students could not organize their learning themselves. These problems perceived by the lecturers interviewed were also documented in studies by Berghoff et al. (2021), Hafer et al. (2021), Neuber and Göbel (2021), Sommer et al. (2021), and Khan et al. (2022), among others, and seem to have been cross-disciplinary and cross-national. The analysis revealed some innovations during the pandemic and breaks with routines. The lecturers used many new digital tools to ensure interaction and scientific exchange, found new forms of organization and combinations of synchronous and asynchronous teaching, created their own new media for teaching to increase student motivation and self-organization, which they partly made available as open educational resources, and found many creative ways to replace their practical courses. Similar approaches can be found in the study by Romero Oliva et al. (2022), among others.

The main types of innovation described above can be found often in both the Panamanian and the German interviews. However, the main differences between the countries were mainly the result of the different lecture formats that were common before the pandemic. Before the pandemic, the German lecturers sometimes held very large lectures with 200–400 students, in which hardly any active participation by the students was possible apart from asking questions. During the pandemic, this type of course was provided mainly through recorded and improved digital material for asynchronous teaching enriched with exercises. In addition to the lectures, there were student-led tutorials, seminars and exercises before the pandemic, which were prepared and partially moderated with students. The participation of students in these types of courses was intensive and during the coronavirus period the lecturers attempted to reproduce this primarily through synchronous digital courses supplemented by digital consultations with the responsible student groups. On the other hand, there were courses before the pandemic that consisted of a mixture of lectures, exercises and seminars at the Panamanian University. These were courses with around 40–80 participants, where lecturers provided input and students gave presentations, exercises and project work. This type of course was conducted entirely through synchronous digital events via video conferencing during the coronavirus period, with supplementary digital material provided for preparation and follow-up.

Our survey period was at the beginning of 2022, when the two universities were still closed and the lecturers had already gained experience in distance learning for a 2 year period. The results regarding the innovations which came from the coronavirus period that the lecturers want to use after the pandemic therefore refer to the respondents' ideas and wishes and do not represent descriptions of actual teaching they have gone on to undertake. A main result to the research question "To what extent do lecturers want to maintain or further develop the didactic innovations they made in their teaching after the pandemic?" is that the respondents primarily want to implement the ideal of digitally supported face-to-face teaching in the future. This result is also in line with the study by Berghoff et al. (2021). In this context, the academic and personal exchange should be in the foreground, whereby various digital tools, which the lecturers have learned to appreciate during the coronavirus pandemic, should be used for presentations, project development, coordination and feedback. In addition, high-quality didactic teaching materials should be developed, preferably as open educational resources, which the students should use to prepare for and follow up on the classroom events, as well as for individual asynchronous digital events. Whereby several studies point out that especially the theoretical contents are suitable for digital teaching (Pillaca-Medina et al., 2022). In addition, the lecturers would like to see flexible forms of face-to-face teaching, synchronous and asynchronous distance learning. This would mean that not all courses take place at fixed times and with standardized length in the universities.

Whether the didactic innovations from the coronavirus period will last in the long term and improve teaching depends not only on the wishes, ideas and positive evaluations of the lecturers, but also on institutional and political decisions at the meso and macro levels (Brennan et al., 2014, see Figure 1). The interviewees regularly referred to these levels when they emphasized the need for technical equipment and software for digital courses, professional support in the creation of digital teaching material or institutional guidelines that enabled flexible teaching and working hours for lecturers. Based on the results presented, it would be desirable to repeat the study in a few years and examine the actual effects and interaction of the levels of innovation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Verbal informed consent was obtained from each participant and confirmed by their active agreement to have the interview audio recorded (via a button in Zoom or Microsoft Teams).

Author contributions

AB, EQ-R, and NS-K designed the study, conducted and analyzed the interviews, and revised the manuscript. AB wrote the first version of the article without the methodological part. EQ-R and NS-K wrote the first version of the methodological part. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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