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The Role of Feedback Type and Peer Interaction in Knowledge Acquisition in a Flipped Classroom on Social Science Research Methods

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Abstract: The flipped classroom approach has increasingly been implemented in higher education and has shown promise for enhancing learning processes across many domains. In this instructional method, learners use certain learning materials to prepare for in-class lessons focusing on a deeper understanding and application of knowledge. Feedback and peer interaction are known to be able to facilitate such higher-order processing. However, questions remain about the extent to which they can enhance the effectiveness of flipped classrooms in higher education. To examine these questions, we employed a 2 × 2 quasi-experimental design in a flipped classroom course on empirical research methods in the social sciences (N = 105). We investigated the effects of the type of feedback (knowledge of correct response vs. elaborated) during a quiz on declarative knowledge, and peer interaction during an application-oriented exercise (individual learning vs. cooperative learning). Elaborated feedback exerted a significant, medium-sized effect on declarative and application-oriented knowledge. A mediation analysis showed that about half of the effects of the type of feedback on application-oriented knowledge were mediated by declarative knowledge. The results implicate elaborated feedback as an effective tool for fostering declarative knowledge acquisition in flipped classrooms. Subsequently, this process also positively influences the formation of application-oriented knowledge during the in-class learning phases.

Keywords: flipped classroom; feedback; peer interaction; application-oriented knowledge; higher education.
DOI: https://doi.org/10.31757/euer.722

Introduction

The flipped classroom approach is widely used as an instructional method for fostering active learning in higher education (Bredow et al., 2021). In traditional lectures, an instructor's in-class teaching of declarative knowledge is followed by its out-of-class application. However, in flipped classrooms, students are exposed to learning materials before class, and individually acquire declarative knowledge. In a subsequent in-class learning phase, students test and apply this knowledge with support from lecturers.

Over the past decade, more and more research has added to the foundation of knowledge on flipped classrooms, including in specific domains, such as engineering education (Lo & Hew, 2019). Meta-analytic evidence has shown that this teaching strategy is effective across various disciplines (Strelan et al., 2020). As the general potential of flipped classrooms has been acknowledged repeatedly, further research has aimed to understand the mediating relationships and moderating conditions of the effects of flipped classrooms. Among others, this includes more detailed investigations of factors influencing student engagement (Lai et al., 2021), interaction as a mediator in learning satisfaction and perceived learning (Lin et al., 2022), and the influence of teachers on learning in flipped classrooms (Buhl-Wiggers et al., 2023). However, there is another angle to these differences in learning outcomes with flipped classrooms: a lack of insight into the optimal instructional design of flipped classrooms. Proven strategies for enhancing student learning may help in understanding and improving flipped classroom designs.

The following question arises: How can flipped teaching be optimally leveraged to support the knowledge acquisition of students? This question is especially relevant for difficult topics such as research methods, as unfamiliarity with scientific practices, high perceived difficulty and lacklustre teaching practices can lead to a paradoxical resistance of students to active learning practices, such as flipped classrooms (Owens et al., 2017). In this context, we aim to examine the potential of instructor feedback and peer interaction as complementary tools to support knowledge acquisition in flipped classrooms.

Knowledge Acquisition in Flipped Classrooms

When students prepare for in-class lessons, they are expected to establish a common foundation of knowledge on the subject. This usually takes the form of information about terminology, facts, classifications, and theories (declarative knowledge). The following face-to-face component of flipped teaching allows students to test their knowledge, ask questions, work together, and receive feedback. Therefore, it lends itself to the application of knowledge in order to deepen understanding (application-oriented knowledge; Sailer & Sailer, 2021). This approach matches Bloom's taxonomy of educational objectives (Bloom, 1956; Buhl-Wiggers et al., 2023). It can illustrate how flipped classrooms aim to facilitate higher-order processing, such as the improvement of skills (Munir et al., 2018), through active learning methods.

Role of Feedback in Flipped Classrooms

In flipped classrooms, students often prepare for in-class lessons autonomously and with limited guidance. When previously learned knowledge is then applied or tested in the classroom, the teacher's role predominantly becomes that of a guide and provider of feedback instead of a knowledge disseminator.

Feedback constitutes a formative assessment of learners' progress and performance (Shute, 2008). It helps lecturers evaluate and readjust their teaching, while learners are shown where and how to improve. Formative assessment has been proposed as effective for low achievers (Black & Wiliam, 2009) and in self-regulated learning (Clark, 2012). While lecturers often provide feedback, students may also be agents of formative assessment through self- and peer feedback (Granberg et al., 2021).

Feedback serves as an important support mechanism to help learners assess their individual performance and understanding of learning materials (Hattie & Timperley, 2007). There has been meta-analytic evidence of feedback showing medium effect sizes on student learning (Wisniewski et al., 2020). However, the authors argue that feedback should not be understood as a single, consistent form of treatment. Instead, its effects are instead largely dependent on the content of the information and the type of learning outcome. However, other potential factors, such as learners' proficiency and setting (Kang & Han, 2015), were not considered in the meta-analysis. As a result, questions remain about the exact mechanisms of feedback in the classroom.

Against this background, teacher feedback can be considered especially important in flipped classrooms, with evidence of increased student performance through elaborated feedback (EF; Thai et al., 2017, 2020). In contrast to simple feedback, which shows whether answers on a test are correct or incorrect (knowledge of correct response or KCR), EF provides additional information, such as explanations and examples (Shute, 2008). Therefore, it may be more effective in supporting the acquisition of declarative knowledge than KCR feedback (Attali & van der Kleij, 2017). Meta-analytic evidence has shown that the combination of KCR and EF is generally effective in supporting learning processes (van der Kleij et al., 2012). However, high-information feedback that includes input on the task or process at hand may be more effective than simple corrective feedback (Wisniewski et al., 2020). In other words, students are generally assumed to strongly profit from feedback a) that explains why certain answers are (in)correct and b) that provides additional contextual information. Nevertheless, numerous studies have shown that participating in tests on previously studied information can be conducive to student learning (Rowland, 2014). As a result, KCR feedback is still assumed to have positive effects on learning. The question is whether EF has an additional beneficial effect on learning outcomes in flipped classrooms.

Peer Interaction and Cooperative Learning in Flipped Classrooms

Flipped classroom designs facilitate the implementation of cooperative learning. In both instructional methods, teachers act as supportive enablers of learning. In-class lessons in flipped classrooms provide a sufficient amount of time and opportunity for cooperative learning, as the main knowledge dissemination phase has already taken place. Consequently, in-class lessons in flipped classrooms are often supported by cooperative learning as an active, student-centric learning method (DeLozier & Rhodes, 2017; Erbil, 2020). Here, lecturers act as task-setters and provide a structured learning environment (Loh & Ang, 2020).

Cooperative learning is a widely used instructional method in which students support each other in their learning processes (Slavin, 1995). Within this approach, teachers facilitate group learning by establishing small groups of students. These groups can vary in size, and group members may perform individual or collective tasks (Slavin, 2016). This approach has wide theoretical support (Jacobs & Seow, 2015), and has been used in many domains and educational levels (Slavin, 2016). Evidence shows that cooperative learning may improve knowledge acquisition and retention, student attitudes, as well as higher and critical thinking skills (Loh & Ang, 2020) compared with individual learning. Multiple meta-analyses have confirmed the academic and social benefits of cooperative learning for students (Gillies, 2016).

Johnson and Johnson (2009) identified five key elements of successful cooperative learning: positive interdependence (I), promotive interaction (II), individual accountability (III), negotiating or teaching social skills (IV), and group processing (V). In other words, group members need to feel responsible for accomplishing the task at hand to ensure positive cooperative learning. They also need to be willing to share resources and provide help, and even challenge each other to facilitate reaching the collective group goal. Each member needs to feel responsible for their own part of the task and needs to be sufficiently trained in interpersonal group work to ensure productive cooperation. This includes being respectful of others' contributions and considering varying levels of knowledge among group members. Finally, they need to be able to identify and reflect on the approaches and level of progression of the task (Gillies, 2016).

Cooperative learning groups are usually small (Slavin, 2016). Small-group inquiry may help students actively engage with course material and subsequently acquire knowledge that can be applied to different situations (Cooper & Robinson, 2000). Small groups are generally reported as being more conducive to learning than larger groups, especially for challenging tasks (Michaelsen & Sweet, 2011) and can improve retention and transfer efficiency (Kirschner et al., 2009).

In cooperative learning, group members share and consolidate knowledge. Feedback seeks to facilitate knowledge generation and enhance performance, while prior knowledge has previously been identified as playing a role in cooperative learning (Oortwijn et al., 2008) and other forms of small-group learning (Zambrano et al., 2019). Therefore, interactions between cooperative learning and feedback should be assumed. It is possible that cooperative learning in flipped classroom settings will be more successful with EF, as it may lead to a better foundation of knowledge for the group task. Conversely, simpler feedback, such as KCR, might lead to different levels of knowledge among group members. This, in turn, may actually help foster positive interdependence and promotive interaction in flipped classrooms.

Research Questions

Both targeted forms of knowledge are assumed to be linked: if there is little declarative knowledge through insufficient student preparation, it can hardly be applied, thus negatively affecting the acquisition of application-oriented knowledge. However, supporting the testing and contextualisation of information through instructor feedback could aid in improving declarative knowledge acquisition, which could facilitate application-oriented knowledge acquisition for students. Correspondingly, it is possible that group learning activities could support the application-oriented process as group members contribute and build on each other's knowledge. In addition to the abovementioned state of research, Nihalani et al. (2011) showed positive effects of feedback on undergraduates' work with a computer simulation but negative effects of collaboration in one experiment. The authors also reported interactions between these educational procedures. Another study by Krause et al. (2009) found beneficial effects of feedback but not cooperation on learning outcomes in an e-learning context. Therefore, the present study seeks to apply this line of investigation to flipped classrooms in order to reach conclusions on how to improve them in practice.

Against this background, the following research questions and assumptions were formulated:

RQ1: To what extent do the type of feedback provided (KCR vs. elaborated), peer interaction (individual learning vs. cooperative learning) and their interaction affect the acquisition of declarative and application-oriented knowledge?

Based on the background and findings discussed in the previous section, we assume a stronger effect of EF on declarative and application-oriented knowledge acquisition than KCR feedback. Similarly, cooperative learning is hypothesised to have a stronger effect on application-oriented knowledge acquisition than individual learning.

RQ2: To what extent are the effects of the type of feedback and peer interaction on application-oriented knowledge mediated by declarative knowledge?

The acquisition of application-oriented knowledge is expected to be affected by feedback and peer interaction. In addition, a mediating effect of declarative knowledge is assumed to occur for these processes. This means that for our data, declarative knowledge should influence and partly explain the effects of the type of feedback on application-oriented knowledge.

Methods

Participants and Study Design

A total of 105 students (n = 15 male and n = 90 female) in the social sciences attended two established introductory courses on research methods in media research at a German university. The participants could be reasonably assumed to be novices on the lecture's topic, as a preliminary test on prior knowledge showed an average performance of M = 6.60 points out of 16, SD = 2.18, CI 95% [6.00, 7.20], with no significant differences between the conditions. Prior to the measurements, which consisted of anonymised surveys and questionnaires, all participants were informed of the study, its background, and the voluntary nature of their participation. Anonymity was ensured by having the participants choose unique personal identifiers that were used to track and link measurements for each case. Students who missed measures in two or more sessions were excluded from the analysis. In addition, n = 3 participants could not be matched to any condition through their identifiers, as reported in Table 1. Aside from remaining incomplete cases, 54 full data cases across all measurements were used for complete cases analysis.

The factors type of feedback (KCR vs. elaborated) and peer interaction (individual learning vs. cooperative learning) were varied in a 2 × 2 between-subjects quasi-experimental design, resulting in four conditions. Table 1 shows the distribution of the participants across the conditions. Each condition was assigned to a different time slot as a separate course. Restrictions in academic teaching procedures did not allow for the randomised allocation of students. Instead, students independently chose course affiliations based on available time slots and without knowledge of these factors. This approach was thought to maximise participation in the study, as overlap with mandatory courses due to students' differing schedules could be avoided.

Table 1

Distribution of the participants among the conditions

n = 3 participants could not be matched to any condition		**Peer interaction**	
		Individual learning	Cooperative learning
Feedback	KCR	*n* = 26	*n* = 25
	Elaborated	*n* = 28	*n* = 23

Course Design

The course was designed as a flipped classroom and took place exclusively online, keeping in line with COVID-19 restrictions at the time. It spanned one semester, with each session lasting roughly 60 minutes. Table 2 presents a visualised breakdown of the course structure.

The students prepared for each in-class lesson beforehand by reading learning materials on the upcoming topic, such as questionnaire design. These materials consisted of presentation slides and supplementary passages from textbooks, ranging from a minimum of five pages to a maximum of 16 pages in length. All of these materials were provided digitally through the university's learning management system one week before the next corresponding in-class lesson. The students were informed by messages when a topic's materials had been uploaded. This procedure resulted in a repeating, alternating pattern of preparation and lesson.

All five in-class learning phases started with an instructional video that consisted of 12-25-minute slide-based instructions by the course lecturer. The aim was to establish a shared foundation of knowledge, as individual out-of-class preparation was self-regulated. The video was followed by a quiz on declarative knowledge using an online quiz app, during which performance was measured. After each question, immediate feedback was given by the application and/or instructor. Following the quiz, a task was presented to the students. Examples include a cloze on diagnostic criteria or conducting a short quantitative content analysis. A test of application-oriented knowledge was then conducted to conclude the lectures and assess student performance. As each lesson's topic varied, only short-term effects were measured. After each lesson, best practice solutions for the tasks were made available on the university's learning management system.

Table 2

Course structure for each lesson

Learning activity	Independent variable manipulated	Phase of flipped classroom
Out-of-class preparation		Pre-class
Instructional video		In-class
Test on declarative knowledge	Feedback (KCR vs. elaborated)	In class
Task	Peer interaction (individual learning vs. cooperative learning)	In-class
Test on application-oriented knowledge		In-class

Experimental Variation

Feedback

During the feedback phase, the type of feedback was manipulated. Students received either automatic KCR feedback by the application or EF by the instructor. The application simply displayed the correct and incorrect answers on the screen for each question. Conversely, the instructor additionally explained *why* particular answers were correct or incorrect while also providing further contextual information based on the contents of the learning materials previously provided.

Peer Interaction

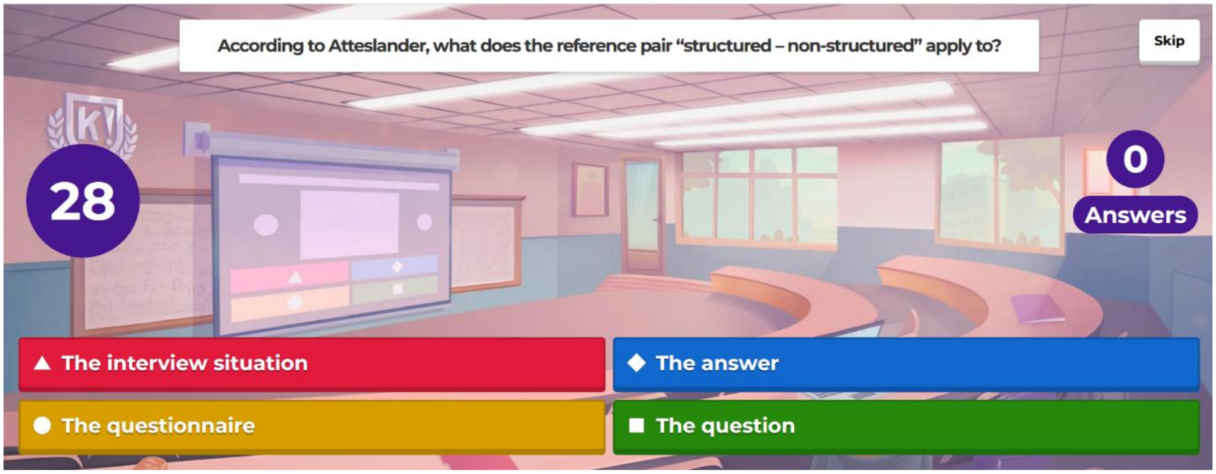
Peer interaction was manipulated during the assigned task. The students in two of the experimental conditions individually solved the assignment while the students in the other two conditions cooperatively worked in small groups of three to five. Zoom allows for the set-up of so-called breakout rooms, to which students may be randomly or manually assigned. These rooms constitute smaller video calls separate from the main session, and only those inside a particular room may talk to each other. Session administrators may also join breakout rooms for communication purposes or send messages to specific or all participants across breakout rooms. Students were randomly assigned to these virtual spaces each time to avoid rigid social clusters. Across all conditions, sufficient time was given to all learners to complete the task. Group work was loosely monitored to assess whether the students talked about the presented tasks and problems therein.

Measurement of Variables

Declarative knowledge was tested through 10-question online quizzes. The application *kahoot!* was used to conduct these quizzes, which took place immediately after the instructional videos were watched. *Kahoot!*s simple gamified pointification mechanics (Subhash & Cudney, 2018; Bai et al., 2020) were considered to help in student engagement after the passive instruction phase. Points are awarded for correct answers, but the faster a participant responds correctly, the more points are awarded in the application. Each question had four possible answers, with only one being correct. Thus, each quiz offered a maximum of 10 points for each participant. Students had 30 seconds to answer each question. After this time or if all participants answered the question before that, the correct answer was revealed. In addition, the lecturer pointed out the students with the overall best performances thus far, based on an automatic leaderboard-type feature of the quiz application. Aggregating all tests on declarative knowledge, students achieved M = 5.24 points, SD = 1.35, CI 95% [4.87, 5.60]. Fig. 1 shows an example of a question on declarative knowledge that was used in one of the tests implemented in the quiz application.

Figure 1

Declarative knowledge quiz platform and sample question

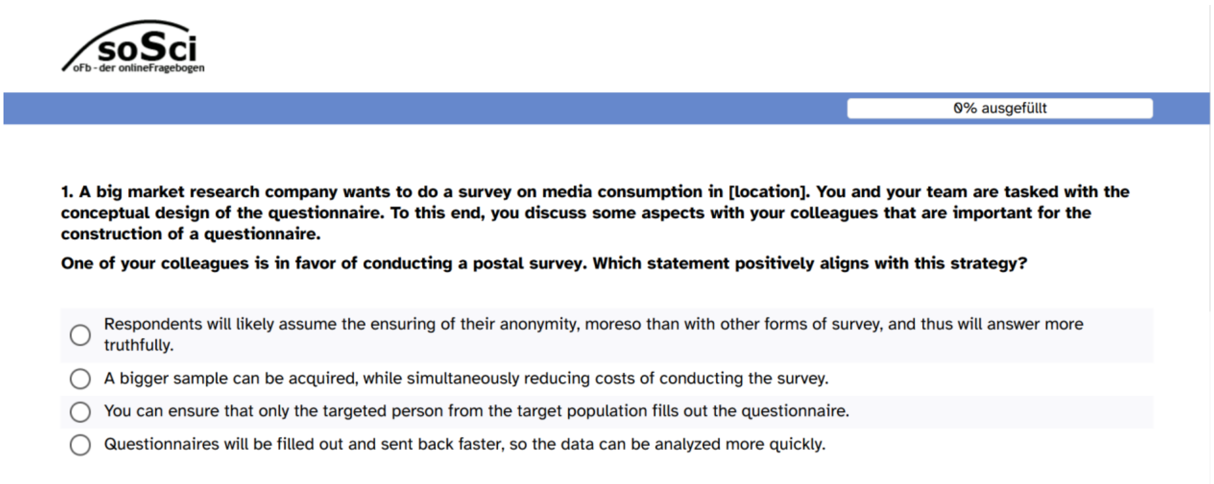


Note: This figure shows the student view of a quiz question on declarative knowledge on the topic of survey research while participating in the quiz through the application *kahoot!*. The coloured panels represent the four possible answers to the question displayed on the ribbon at the top of the screen. To answer, the students press the corresponding coloured square on their smartphones or laptop screens. The circle on the left shows the remaining time limit in seconds, while the circle on the right displays the number of answers given by other participants so far. The question and the choices provided were translated for this manuscript.

For the tests on *application-oriented knowledge*, the participants were given as much time as needed to complete the quizzes, as these questions were often framed in a domain-relevant scenario and thus were generally more complex than those for declarative knowledge. The quizzes also consisted of 10 single-choice questions with four possible answers, for a total of 10 points. The platform *SoSci Survey* was used, which forgoes any gamification elements. No time limit was set for individual questions. On the application-oriented knowledge tests, the students achieved M = 5.36 points, SD = 0.98, CI 95% [5.09, 5.62]. Fig. 2 shows an example of a question on application-oriented knowledge that was used in one of the tests implemented in the survey application.

Figure 2

Application-oriented knowledge quiz platform and sample question



Note: This figure shows the student view of a quiz question on application-oriented knowledge on the topic of survey research while participating in the quiz through the application *SoSci Survey*. The white bar on the blue ribbon at the top of the screen represents a progress bar that approximates the completed portion of the test in percent.
The four possible answers (regular text) to the question (bolded text) are displayed next to circles, which are clicked to choose or re-choose any single answer at a time before continuing to the next question. In this example, the first choice is the correct response. The question and choices provided were translated for this manuscript, and the university's location was redacted.

To evaluate the internal consistency reliability of the quizzes, Cronbach's alpha was calculated (Cronbach, 1951; Anselmi et al., 2019). Computed values range from 0 to 1, with higher scores indicating better internal consistency reliability. For declarative knowledge, a value of $\alpha = .56$ was reached. For application-oriented knowledge, the formula yielded a value of $\alpha = .051$. At first glance, these scores seem insufficient for both tests when compared with the threshold of 0.70 and above which is generally seen as acceptable for survey items (Tavakol & Dennick, 2011). However, the tests covered different topics instead of redundantly measuring knowledge in single, narrow concepts. Thus, high values of internal consistency may ultimately not be expected or even desirable for our tests (Taber, 2017). This is because high alpha values may indicate a redundancy of questions (Tavakol & Dennick, 2011), while the quizzes employed in this study aimed to assess a broader range of knowledge in the lesson topics.

Statistical Analyses

To investigate RQ1, an analysis of variance was conducted. We used declarative knowledge and application-oriented knowledge as the dependent variables. Type of feedback and peer interaction served as the independent variables.

To assess RQ2, a mediation analysis was conducted. This analysis tests the extent to which an antecedent variable mediates the effect of an independent variable on an outcome variable (MacKinnon et al., 2007). In a mediation model, the independent variable affects the dependent variable (direct effect). The part of the overall effect that is influenced by the mediating variable is called the mediated or indirect effect. Mediation analyses help to identify these partial effects through multiple regression. While the present sample size can be considered rather small for conducting a mediation analysis, some authors have argued that using the bootstrap method can allow even a range of 20–80 cases to be used in mediation analyses (Shrout & Bolger, 2002). This is because bootstrapping, as a nonparametric resampling method, does not make any assumption on the distribution of data (Chen & Fritz, 2021) and is thus considered among the best practices for investigating indirect effects (Schoemann et al., 2017).

The significance level (alpha) was set to 5% on all tests. The confidence intervals (CI) for the mean values were computed at the 95% level.

Results

RQ1: Students in the condition with cooperative learning and EF performed best on declarative knowledge, as illustrated in Table 3. For application-oriented knowledge, the same group achieved the most points on average (Table 3). The students who received EF instead of simpler KCR feedback scored better on declarative and application-oriented knowledge tests. Similarly, cooperative learning led to better student performance, as opposed to individual learning.

Table 3

Descriptive results for the tests on declarative and application-oriented knowledge (mean, standard deviation, and confidence interval)

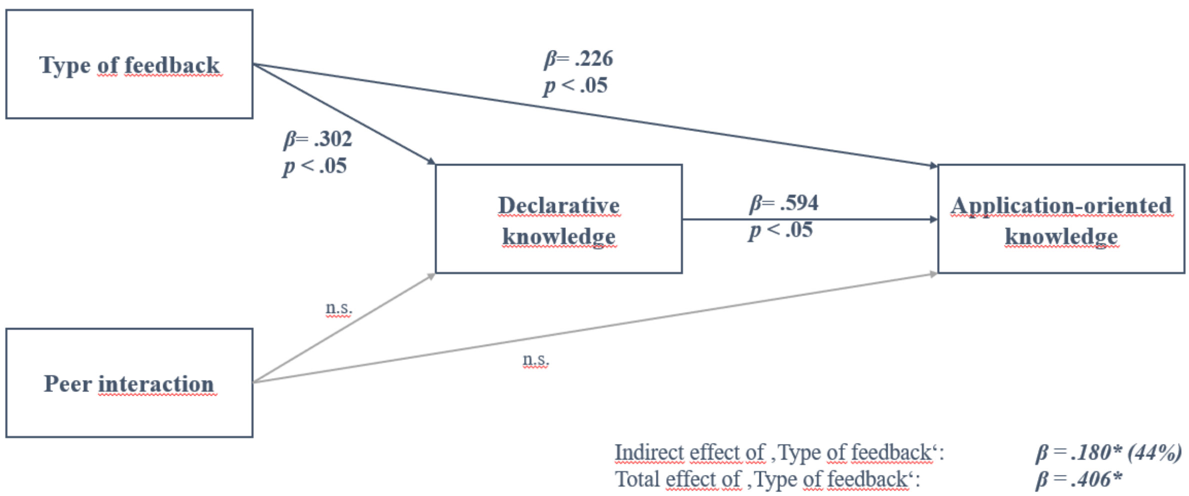
		Peer interaction			
		Individual learning		*Cooperative learning*	
		Feedback		**Feedback**	
		KCR	*Elaborated*	*KCR*	*Elaborated*
Declarative knowledge	*M*	4.55	5.37	5.09	5.89
	SD	1.18	1.63	1.33	0.77
	CI	[3.82; 5.29]	[4.54; 6.20]	[4.44; 5.74]	[5.43; 6.34]
Application-oriented knowledge	*M*	4.79	5.64	5,24	5.67
	SD	0.85	1.02	0.98	0.91
	CI	[4.29; 5.30]	[5.13; 6.15]	[4.76; 5.72]	[5.16; 6.18]

Consistent with our assumption, type of feedback exerted significant medium effect sizes on declarative (η^2 = .086, $F_{1,1}$ = 4.72, p = .0035) and application-oriented knowledge (η^2 = .103, $F_{1,1}$ = 5.92, p = .0019). However, the effect of peer interaction was not significant for either type of knowledge, and neither was the interaction between both manipulated factors. This means that our assumptions are partly confirmed for this research question.

RQ2: As previously mentioned, a mediation analysis was used to test the assumptions that a) application-oriented knowledge acquisition is affected by feedback and peer interaction, and that b) declarative knowledge influences this effect. The mediation analysis showed that the effect of the type of feedback on application-oriented knowledge was partially mediated by declarative knowledge. Peer interaction was not part of the mediating process, as shown in the detailed mediation model in Fig. 3. Altogether, this is partly consistent with our assumption. Type of feedback exerted a total effect size of β = .406, CI 95% [0.29; 1.27] and an indirect effect size of β = .180, CI 95% [0.02; 0.67] on application-oriented knowledge. In other words, roughly half of the effect of feedback on application-oriented knowledge was explained by declarative knowledge.

Figure 3

Mediation model diagram



Note: This figure depicts the variables type of feedback, peer interaction, declarative knowledge and application-oriented knowledge in boxes as part of a mediation model. Declarative knowledge serves as the mediator. The lines represent the direct and indirect effects of the type of feedback and peer interaction on application knowledge. Bolded lines denote the significant relationships between the variables, while regular lines represent non-significant relationships. The arrows indicate the direction of influence.

Discussion

The flipped classroom design was employed during the COVID-19 pandemic and thus took place exclusively online. This resulted in challenges for students and lecturers alike, such as difficulties in assessment for lecturers and an unusually heavy workload for students (Adedoyin & Soykan, 2020). In an online course, the instructor's ability to gauge student engagement may be impeded (Cole et al., 2019). In such settings, feelings of loneliness can more easily arise and negatively affect students' learning experiences. In addition, during this time, the university made use of the online conference tool Zoom, which was used dominantly in education from the start of the COVID-19 pandemic onwards. Thus, low motivation due to "Zoom fatigue" (Wiederhold, 2020) could have also impeded learning processes.

Although the software Zoom offered possibilities for cooperative learning in purely online learning environments, the conditions were arguably not ideal for group work. Due to technical difficulties, motivational factors, ease of anonymity, and Zoom's remote nature, all previously discussed key elements of cooperative learning (Johnson & Johnson, 2009) could have been jeopardised. This also increased the risk of social loafing (Gabelica et al., 2020), in which some team members possibly relied on others to do the brunt of the work on a given task. Indeed, some students reported unbalanced or lacklustre group participation. Although there was random monitoring of group work for the in-class tests, productive interactions conducive to learning could ultimately not be ensured. Moreover, some of the randomly determined groups might not have "clicked" on a given topic, possibly impairing the acquisition of application-oriented knowledge tests. Furthermore, providing auxiliary guidance during cooperative learning sessions should be considered to maximise its potential and more clearly distinguish it from collaborative learning. While additional feedback during this phase was avoided in the present study to prevent the skewing of data, similarities to collaborative learning consequently emerged, in which the lecturer takes on a more hands-off role (Loh & Ang, 2020). Formative assessments of group tasks, measuring attitudes and providing guidelines for teamwork (e.g. collaboration scripts; Vogel et al., 2017) could improve peer interaction and help more accurately investigate the effects of cooperative learning in flipped classrooms.

Overall, the students generally achieved rather low scores on declarative and application-oriented knowledge tests. This could be ascribed to their unfamiliarity with the course's topic or its general difficulty (Tang et al., 2020). Insufficient out-of-class preparation may be another possible explanation (Akçayir & Akçayir, 2018). Building on the interpretation of the high difficulty of the course, it would follow that students who had trouble with the acquisition of declarative knowledge also had trouble applying it to scenarios in the subsequent quiz on application-oriented knowledge. It could be that, in order to generate application-oriented knowledge in a conducive manner, higher values of domain-specific prior knowledge are necessary. The intricacies of the effect of prior knowledge remain a subject of future-focused research (Simonsmeier et al., 2021). Using learning analytics in future studies could also help with identifying potential dropouts early in the study (Sønderlund et al., 2018), as the previously mentioned reduced number of full data cases limits the findings of this study. It is uncertain whether or to what extent motivational factors, technical difficulties or forgetting the individual identifiers are among the causes and how much so. Further analyses are needed to determine the potential biases of interventions on dropouts.

Possible improvements to the course design concern the learning materials used in this study. The length of the instructional videos used for student preparation is contrasted by some empirical evidence. For example, Pi and Hong (2016) reported an increase in learners' mental fatigue after watching 10 minutes of an instructor-present video. This effect might be further consolidated for difficult topics, as is assumed for this course on research methods in the social sciences. Educational practitioners should consider using shorter instructional videos, which could be more effective in teaching challenging learning content. Additionally, implementing interactive elements could also aid in mitigating students' passive learning behaviours.

It has been argued that EF should not provide a correct answer if learners initially chose an incorrect answer (Wang & Wu, 2008). Instead, opportunities to correct responses should be provided to boost learning effectiveness. However, the quiz platform chosen for this study facilitated this procedure, as *kahoot!* does not allow changing chosen answers due to its pointification and leaderboard features. Different applications may vary in their opportunities for providing feedback and its timing. Hattie and Timperley (2007) initially reported inconsistent findings concerning the timing of feedback. Even today, this issue remains nuanced, with different timings seemingly being suited to particular interventions (e.g. immediate feedback as more effective for learning from text; Swart et al., 2019). In addition, feedback was provided by different agents in this study (quiz application vs. lecturer). As a result, it is possible that affective factors played into the differences in the effect of feedback type. More analyses need to be conducted to differentiate the types and timing of feedback in flipped classrooms and the role of human versus machine agents.

One methodical limitation of the present study concerns the mediation analysis. Although the produced sources in the respective sections substantiate its appropriate application, it should be noted that other researchers have observed that bootstrapped confidence intervals can still be erratic for smaller sample sizes. As a result, they recommend samples of at least 100 cases if at least one effect size is expected to be moderate (Koopman et al., 2015). Future research investigating mediated effects in flipped classroom designs should aim to acquire and work with larger samples, if possible.

Conclusion

This study investigated the effects of feedback and peer interaction in an online flipped classroom on social science research methods. The results showed positive effects of EF in a flipped classroom compared with simple KCR feedback. This finding confirms previous evidence concerning the effectiveness of immediate, task-related feedback (Hattie & Timperley, 2007; Krause et al., 2009) in this specific instructional method. Facilitating declarative knowledge acquisition through teacher feedback had a positive effect on the subsequent formation of application-oriented knowledge in this study. However, while facilitating declarative knowledge acquisition through teacher feedback had a positive effect on the subsequent formation of application-oriented knowledge in this study, only half of the effect of feedback on application-oriented knowledge acquisition was explained by declarative knowledge. Further analyses are required to explore the remaining unexplained part of this effect.

In addition to some considerations for future research outlined in the discussion, we propose a few implications for the design of flipped classrooms based on our findings. Flipped classrooms rely heavily on the foundation and application of declarative knowledge. Therefore, thorough consideration should be given to shaping the instructor's role as an active facilitator of knowledge acquisition and influencer of learning processes when designing flipped classrooms. Not only should the contents of learning materials be picked up and elaborated upon by the lecturer in-class, opportunities should also be provided for students with lacklustre preparation to catch up in order to acquire application-oriented knowledge. Educational agents should also consider implementing some form of learning analytics to track preparation for each session and to potentially adapt the lessons to the individual needs of students (Sønderlund et al., 2018). Another point of deliberation concerns course sizes. While active instruction is generally more effective than traditional lecturing, this effect is more pronounced for group sizes below 20 students (Kozanitis & Nenciovici, 2022). A stronger effect also applies to upper-level classes as opposed to introductory courses, like in this study. This means that, when applying the flipped classroom framework to larger courses, additional measures to foster active learning should be considered.

Although cooperation did not show significant effect sizes in the present study, its potentially beneficial effects should not be disregarded entirely. We argue for an adjustment in its implementation, especially given the varying social, motivational, and spatial aspects of teaching during and after the pandemic. Thus, future studies should also investigate the effect of course modality in the different stages of flipped classrooms. Fostering connections between students through cooperation can be especially relevant in online settings (Kaufmann & Vallade, 2020). Whether group tasks are designed to be done online or offline, collaboration scripts (Vogel et al., 2017) that are specifically adapted to the different challenges within the varying kinds of task could help in facilitating smooth and productive group work conducive to learning outcomes.

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Please Cite: Schlag, R., Stegmann, K., & Sailer, M. (2024). The role of feedback type and peer interaction in knowledge acquisition in a flipped classroom on social science research methods. *The European Educational Researcher*, *7*(2), 21–40. https://doi.org/10.31757/euer.722

Conflict of Interest: The authors declare no conflict of interest. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Funding: Not applicable.

Data Availability Statement: The data generated and analyzed within the current study are available from the corresponding author on reasonable request.

Author Contributions: All authors contributed to the present study. Study conception, design, material preparation, and execution as well as data collection were done by Ruben Schlag and Maximilian Sailer. Data analysis was performed by Ruben Schlag and Karsten Stegmann. The first draft of the manuscript was written by Ruben Schlag. All authors read and commented on previous versions of the manuscript. Editing was done by Ruben Schlag. Maximilian Sailer acted as supervisor for the whole process.

Received: January 23, 2024 ▪ Accepted: June 04, 2024