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# Near and far transfer in the flipped mathematics classroom: student's evaluation of learning activities

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*In contrast to traditional forms of instruction, flipped learning enables students and teachers to focus on consolidating knowledge and fostering a deeper understanding of new mathematical content during class time. Both near-transfer problems and far-transfer problems can be the focus of such consolidation during a face-to-face lesson. In this study, we examine how students evaluate different learning activities in a flipped classroom setting when class time is dedicated to near transfer and far transfer, respectively. Results indicate, for example, a general preference for collaborative work, especially during face-to-face lessons that focus on far-transfer. To contextualize the results, we took the teacher's perspective into account. It adds a valuable point of view but is not always compatible with the students' perspective.*

*Keywords: Flipped classroom, Learning activities, Transfer of Learning.*

## Introduction

Flipping the classroom divides students' learning into two phases: the homework phase taking place before class and the face-to-face in-class phase. During the homework phase, students study new content at home, usually with the help of a video (Bishop & Verleger, 2013). Often, such videos focus on different forms of direct instruction (Bergmann & Sams, 2012), such as introductory videos, that explain new mathematical concepts, or illustrative videos, that present worked examples (Voigt et al., 2020). During the in-class phase, face-to-face time can then be used to focus on applying the content studied during the homework phase (Love et al., 2013). This can include various tasks and activities differing in their cognitive demand and the underlying educational objectives. One criterion to characterize different ways of content application in mathematics is the transfer of learning (Tüker, 2013). More specifically, near transfer and far transfer can be distinguished. Near transfer occurs between very similar contexts, whereas far transfer occurs between contexts that seem more remote to each other (Perkins & Salomon, 1994).

## Near and far transfer in the flipped classroom

In a flipped learning environment, near transfer during the in-class phase can refer to tasks and activities in this phase being similar to the content of the video, especially worked examples previously presented in the video. For instance, in the context of teaching the Pythagorean theorem, near transfer occurs when students are given the task to calculate the length of the hypotenuse in a right-angled triangle in class after watching a video at home demonstrating such a calculation based on a different numerical example. Students can apply the algorithm displayed in the video directly in the context of the new task. In contrast, activities and tasks of far transfer in class go beyond the context presented in the video. For instance, far transfer occurs when students watch a video demonstrating how to apply the Pythagorean theorem to calculate lengths for one type of polyhedron,

such as a pyramid, by looking for auxiliary right-angled triangles. In class, they are then asked to transfer this more general strategy to new types of polyhedrons, like cuboids, for example. While near transfer and far transfer are discussed in theory for designing activities for the in-class phase of a flipped classroom (Enfield, 2016), previous research on these forms of transfer in the flipped classroom is scarce or focusses on students' performance, e.g., Harrison et al. (2017). Hence, it has been suggested by Lo and Hwang (2018) that future research on course activities for flipped learning should also take into account near and far transfer as well as student perceptions of such activities. Therefore, we examine student perceptions of flipped learning activities in the context of near transfer and far transfer in this study.

## **Research Questions**

The study aims to compare students' evaluations of learning activities in a flipped classroom for lessons that focus on near transfer and far transfer of the video content during the in-class time (hereafter referred to as near-transfer lessons and far-transfer lessons), respectively. To guide this comparison, we pose the following research questions:

1. How do students evaluate learning activities in the flipped classroom for near-transfer lessons?
2. How do students evaluate learning activities in the flipped classroom for far-transfer lessons?
3. How do students' evaluations of activities in the flipped classroom differ between near-transfer lessons and far-transfer lessons?

## **Methods**

### **Participants**

This study was conducted with students of four classes of the 9<sup>th</sup> grade of two German academic-track secondary schools (Gymnasium) in June 2021 (N = 79). These are schools granting the highest possible secondary school qualification in Germany. Convenience sampling was used to select the participants. The classes were taught by two different teachers. Their experiences in teaching mathematics in general as well as teaching the classes participating in the study were similar. Neither teacher had used the flipped classroom method regularly before this study. However, the teachers implemented flipped learning for several individual lessons before the start of the main study under the authors' guidance to accustom the students to the changed requirements in the flipped classroom (Lo et al., 2017). According to the teachers, students in all classes were familiar with cooperative forms of work, such as working with a partner or in small groups, before the study.

### **Design and Procedure**

The students were taught two back-to-back flipped lessons on the Pythagorean theorem. The flipped lessons were conducted within a longer lesson sequence on the Pythagorean theorem, i.e., the students had prior knowledge of some aspects of the subject matter. However, each flipped lesson introduced new learning contents that had not been taught in previous lessons. The instructional material was designed and provided by the first author of this paper. During the homework phase of each lesson, students worked with an instructional video of nine to twelve minutes. These videos can be classified as illustrative videos (Voigt et al., 2020) since they contained worked examples or solutions for different problems related to the Pythagorean theorem, e.g., calculating the missing length of a side

in a right-angled triangle or calculating the edge lengths of pyramids. Each video was accompanied by a short task relating to its content as an incentive for students to prepare for class (Kim et al., 2014). Completing these tasks, including watching the video, takes an estimated time of 30 minutes. The following in-class phase consisted of a face-to-face lesson of 90 minutes. It started with comparing students' solutions to the task related to the video and clarifying problems or questions. The remaining time of the lesson was devoted to exercising and consolidation. Here the two flipped lessons differed. Students' tasks for consolidation focused on near-transfer problems in one lesson and far-transfer problems in the other lesson. However, both lessons provided differentiated tasks according to students' level of prior knowledge and the opportunity for students to determine the pace of working through those tasks themselves. Furthermore, students could decide to work collaboratively with a partner or in small groups. For most tasks, students could also opt for working on their own if they preferred. During this phase, the teacher acted as a "guide on the side" (King, 1993), answering questions and providing scaffolding if necessary. At the end of each flipped lesson, students completed a survey evaluating the learning activities of the lesson. One teacher taught the near-transfer lesson before the far-transfer lesson. In classes of the other teacher, it was vice versa.

### **Instruments and Data Analysis**

For the post-class survey, an adapted version of the Student Assessment of their Learning Gains (SALG) instrument (Seymour et al., 2000) was used after the near-transfer lesson and again after the far-transfer lesson. Students' evaluations of how much the learning activities in the flipped classroom helped their learning were gathered on a 5-point Likert scale ranging from 1 (no help) to 5 (great help). Since this does not constitute an interval scale, non-parametric tests were used for data analysis (Rasch et al., 2010). For students who did not engage in certain activities during a lesson, e.g., individual work, the option 'not applicable' was given in the questionnaire. In total, 75 students completed the survey after both flipped lessons. Four students, who only completed one of the two surveys, were excluded from the study. To determine whether students' evaluations for the individual activities during the near-transfer lesson and far-transfer lesson themselves differed, we applied the Friedman test for comparing multiple dependent samples (Janssen & Laatz, 2017). Since a comparison of all evaluated activities would not allow a meaningful interpretation, multiple Friedman tests were conducted for groups of related activities, e.g., comparing types of collaborative work. For the Friedman test, a post hoc analysis is necessary (Janssen & Laatz, 2017). Therefore, pairwise comparisons were conducted within each group using the Bonferroni correction. For further separate analysis of activities during the near-transfer lesson and the far-transfer lesson, the correlation between students' evaluation of the individual activities and their level of prior knowledge was examined through Spearman's rank correlation coefficient  $r_s$  for ordinal data (Janssen & Laatz, 2017). For this purpose, students were ranked into three groups according to their level of prior knowledge (low, average, and high) based on grade point average. Since students could choose not to do certain activities, missing data had to be taken into account. Therefore, a  $\chi^2$ -test for the independence of nominal data (Rasch et al., 2010) was conducted to determine whether the decision against a specific type of activity depends on the students' level of prior knowledge for each form of transfer. Another  $\chi^2$ -test was conducted to examine whether the decision against a specific type of activity during the near-transfer lesson coincides with such a decision in the far-transfer lesson. Finally, differences in

students' evaluations of activities during the near-transfer and the far-transfer lesson were analyzed using the Wilcoxon signed-rank test for comparing two dependent samples (Rasch et al., 2010). All tests were applied at a significance level of 0.05 using SPSS. To contextualize the results of the SALG, we added an open-ended question to the surveys asking students to elaborate and explain their assessment. Furthermore, an interview with the teachers was conducted to gather an assessment on student learning from an observer perspective. The students' answers to the open-ended survey question and the teachers' statements were analyzed by the authors applying a thematic coding strategy (Kuckartz, 2010). When differences in the analysis occurred, the corresponding segments were discussed further until consensus was reached.

## Results

### Evaluation of learning activities for near-transfer lessons

Table 1 displays the evaluation results of the near-transfer lesson for all activities. The Friedman test for the different types of collaborative work, i.e., individual work, partner work, and group work, indicates significant differences ( $\chi^2(2, n = 47) = 38.38, p < .001$ ). Post hoc analysis demonstrates that individual work was rated as significantly less helpful compared to partner work ( $z = -4.95, p < .001$ ) and group work ( $z = -3.89, p < .001$ ), respectively. However, the difference between partner work and group work evaluations was not statistically significant ( $z = 1.08, p = .836$ ). Students' statements in the open-ended survey question yielded the same results with students describing both partner and group work mainly as a possibility to exchange ideas and thus to reach the goal faster.

**Table 1: Evaluation results of individual learning activities for the near- and far-transfer lesson**

Learning activity	near-transfer lesson			far-transfer lesson		
	n	M (SD)	Mdn	n	M (SD)	Mdn
<i>Video-related activities</i>						
Watching the instructional video at home	70	4.00 (0.87)	4.00	71	4.01 (0.80)	4.00
Completing tasks related to video at home	73	3.41 (1.05)	3.00	66	3.42 (0.96)	3.00
Comparing results of video-related tasks in class	62	4.02 (0.98)	4.00	71	4.13 (0.97)	4.00
<i>Types of explanation</i>						
Hearing explanations by the teacher in class	73	4.23 (0.84)	4.00	73	4.22 (0.97)	4.00
Participating in discussions in class	48	3.40 (1.22)	3.50	60	3.77 (1.06)	3.50
Hearing other students explain their work in class	51	3.49 (1.07)	4.00	65	3.23 (1.09)	4.00
Interacting with the teacher in class	65	4.34 (0.76)	4.00	65	4.63 (0.65)	4.00
Explaining my work to other students in class	47	3.19 (1.23)	3.00	64	3.13 (1.15)	3.00
<i>Collaborative work</i>						
Participating in group work in class	50	4.04 (0.95)	4.00	72	4.26 (0.89)	4.00
Participating in partner work in class	67	4.18 (0.82)	4.00	69	4.12 (1.02)	4.00
Studying on my own	69	3.32 (1.08)	3.00	65	3.08 (1.16)	3.00
<i>Other</i>						
Working at my own pace	75	4.32 (0.83)	5.00	75	4.39 (0.80)	5.00
The overall approach to teaching and learning	75	4.15 (0.73)	4.00	74	4.12 (0.78)	4.00

For the five different types of explanation (see table 1), the Friedman test also indicates significant differences ( $\chi^2(4, n = 37) = 45.59, p < .001$ ). In this case, post-hoc pairwise comparisons revealed that interaction with the teacher was evaluated as significantly more helpful than participating in discussions ( $z = -3.01, p = .026$ ), hearing other students explain their work ( $z = -3.57, p = .004$ ) or explaining one's own work ( $z = -4.96, p < .001$ ), respectively. Furthermore, hearing explanations from the teacher was rated significantly higher than hearing other students explain their work ( $z = 2.98, p = .029$ ) or explaining one's own work ( $z = 4.38, p < .001$ ). Between other pairings no significant differences were found. Using  $\chi^2$ -tests for further examination of missing data, i.e., occurrences of the evaluation 'not applicable', did not reveal any significant relationships between the choice not to partake in a specific learning activity and the students' level of prior knowledge. Furthermore, the application of Spearman's rank correlation coefficient did not indicate a significant correlation of the students' level of prior knowledge and their evaluation of any learning activities during the near-transfer lesson.

### **Evaluation of learning activities for far-transfer lessons**

The evaluation results of the far-transfer lesson for all activities are also displayed in table 1. Similar to the results for the near-transfer lesson, the Friedman test for the different types of collaborative work suggests significant differences ( $\chi^2(2, n = 60) = 49.69, p < .001$ ). Again, post hoc pairwise comparisons indicate that individual work was rated significantly lower compared to partner work ( $z = -5.02, p < .001$ ) and group work ( $z = -5.39, p < .001$ ), whereas the difference between partner work and group work was not statistically significant ( $z = -0.37, p = 1.000$ ). The explanations for this rating given in the open-ended survey question do not differ from those for the near-transfer lesson. The Friedman test for the five different types of explanation indicates significant differences ( $\chi^2(4, n = 50) = 84.79, p < .001$ ) during the far-transfer lesson, too. Post hoc analysis is comparable to the near-transfer lesson revealing that interaction with the teacher was again evaluated significantly higher than participating in discussions ( $z = -3.92, p = .001$ ), hearing other students explain their work ( $z = -6.19, p < .001$ ) or explaining one's own work ( $z = -7.18, p < .001$ ), respectively. Once again, hearing explanations from the teacher was rated as significantly more helpful than hearing other students explain their work ( $z = 4.05, p = .001$ ) or explaining one's own work ( $z = 5.03, p < .001$ ). However, unlike during the near-transfer lesson, the activity of participating in discussions was rated as significantly more helpful than explaining one's own work to others ( $z = 3.26, p = .011$ ). No other significant differences were found. As was also the case for the near-transfer lesson, no significant relationships were found between students' level of prior knowledge and their evaluation of any of the learning activities of the far-transfer lesson or their choice not to partake in any specific activities during this lesson. This result is not consistent with the results gathered during the teacher interview. One teacher voiced the opinion that flipped learning as an overall approach is not as suitable for students with a low level of prior knowledge. The other teacher expressed the opposite view that activities of the homework phase are especially suitable for such students if they exhibit a certain level of diligence.

## Comparison of the near-transfer lesson and the far-transfer lesson

The Wilcoxon signed-rank tests indicate significant differences in students' evaluations between both lessons only for some of the learning activities. Students' evaluations rated individual work ('Studying on my own') during the near-transfer lesson statistically significantly higher than during the far-transfer lesson ( $z = -2.21$ ,  $p = .027$ ,  $n = 61$ ). In contrast, group work was rated significantly less helpful during the near-transfer lesson than during the far-transfer lesson ( $z = -3.00$ ,  $p = .003$ ,  $n = 49$ ). A similar result was found for (individual) interaction with the teacher, which was also rated significantly less helpful during near-transfer lessons than during far-transfer lessons ( $z = -3.05$ ,  $p = .002$ ,  $n = 62$ ). For certain types of explanations, one-sided hypotheses were formulated. In the case of the activity of 'hearing other students explain their work', it was assumed that during far-transfer lessons, students would be able to produce fewer mathematically correct explanations than during near-transfer lessons. Thus, it was expected that the helpfulness of this learning activity would be ranked higher during the near-transfer lesson than during the far-transfer lesson. This was confirmed by the Wilcoxon signed-rank test ( $z = -1.83$ ,  $p = .067$ ,  $n = 48$ ). Since rank differences occurred in the predicted direction, this result can be interpreted as statistically significant in accordance with the one-sided hypothesis. For the other learning activities evaluated with the SALG, no significant differences between the near-transfer and far-transfer lessons were found. Comparing the occurrence of the evaluation 'not applicable' for the learning activities during both lessons, the  $\chi^2$ -test revealed a significant relationship for the activities of explaining one's own work to others ( $\chi^2(1, n = 71) = 10.81$ ,  $p = 0.001$ ), hearing other students explain their work ( $\chi^2(1, n = 70) = 8.89$ ,  $p = 0.003$ ) as well as interaction with the teacher ( $\chi^2(1, n = 74) = 36.21$ ,  $p < 0.001$ ) during class. Students who did not partake in one of those activities during the near-transfer lesson were also unlikely to partake in the same activity during the far-transfer lesson.

## Discussion

In the previous section, we have examined how students evaluate different learning activities in a flipped classroom setting when class time is dedicated to near transfer and far transfer, respectively. Most of the results were to be expected, and student comments and teacher interviews largely confirm the statistical results. However, the comments and interviews cast an interesting eye on the following aspects. As generally expected, partner and group work were both rated significantly more helpful than individual work. Also, the significantly higher evaluation of individual work in near-transfer lessons in contrast to far-transfer lessons is in line with our expectations, since here tasks and activities are similar to the content of the video. In contrast, this is hardly evident from the student comments, which focus almost exclusively on the partner and group work. However, this omission can be explained by observations of one of the teachers: the students frequently opted for partner or group work during the near-transfer lesson, but observing them, one got the impression that everyone completed the tasks on their own without any exchange in between them. During the far-transfer lesson, the teacher observed a much more vivid exchange during the group work. This comparison suggests creating opportunities for individual work phases in near-transfer lessons and offering more possibilities for group work in far-transfer lessons, a concept that needs further investigation. Nevertheless, the role of the teacher should not be underestimated during individual and collaborative work. In both the near-transfer lesson and the far-transfer lesson, students find explanations by their

peers to be less helpful than explanations by the teacher. Especially interacting with the teacher, which can provide the opportunity to clarify individual problems, seems to be more important during far-transfer lessons than during near-transfer lessons. This was reflected in students' comments in the open-ended survey question which consistently emphasized the importance of interacting with others during group work, including the teacher. Another aspect worthy of discussion concerns the level of prior knowledge. The teachers assessed the suitability of flipped learning activities differently depending on students' level of prior knowledge. In contrast, the survey results suggest that students' preferences for any of the given types of activities do not correlate with their level of prior knowledge neither for near-transfer lessons nor for far-transfer lessons. This can also be seen from analyzing the occurrences of the answer 'not applicable' in the survey. A students' choice to not engage in certain types of activities at all (like interacting with a teacher) during a lesson cannot be explained by their level of prior knowledge in our study. Instead, a comparison of the near- and far-transfer lesson suggests that the more likely explanation for not choosing certain activities is that there are students who generally communicate less on an individual level with a teacher or other students during lessons. This effect seems to be independent of the teaching design.

## Conclusion

In summary, our results show that students appreciate the possibility to work in groups during the in-class phase of a flipped classroom, both in near- and far-transfer lessons. The qualitative part of the study suggests focusing on individual work during near-transfer and group work during far-transfer lessons. A correlation between students' preference for certain types of activities and their level of prior knowledge could not be detected. This could be superimposed by other variables, especially aspects of behavioral engagement (Cevikbas & Kaiser, 2021). Traditionally, research on engagement in the flipped classroom focuses on the influence of flipped learning on student engagement (Bond, 2020). We suggest that further research also investigates the reversed case, i.e., the influence of student engagement on learning activities in a flipped classroom, particularly video-related activities.

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