Flipped classroom: Effects on the conceptional understanding in electric circuit teaching

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Abstract. On the basis of a design-based research approach, a learning environment suitable for the application of flipped classroom was developed for teaching simple electric circuits. A large-scale assessment was used to evaluate the effects. This learning environment included diverse digital offers and various practical in-class exercises. In addition to the teaching concept, this contribution discusses the effects of flipped classroom on the development of conceptional understanding. It particularly differentiates whether the effects are caused by the underlying didactic concept and the thus created learning materials, by the flipped classroom method, or a combination of the two.

Introduction

Pupils bring numerous misconceptions about electric circuits from daily life to class [1]. Even after the topic was covered in class, pupils keep many of these misconceptions due to their often poor conceptional understanding of electric circuit basics [2]. This study shows that pupils who used certain materials on electric circuits based on the free electron model and who were taught using the method flipped classroom, were able to develop a deeper conceptional understanding than the pupils of a control group.

Study design, teaching concept, and data

This contribution is based on data sourced during field studies on flipped classroom at Bavarian secondary schools. The core idea of the flipped classroom method is to shift knowledge development to the preparation phase at home, so that the supervised learning time in class can mainly be used for deepening understanding, for exercises, and discussions [3]. This contribution examines the effects of the application of the flipped classroom method and the development of conceptual understanding of pupils regarding simple electric circuits.

N=2178 female pupils (n=1217) and male pupils (n= 961) of the eighth grade participated in the study. Depending on the chosen specialisation (branch), the pupils are taught three Physics lessons (NTG-branch), or two Physics lessons (non-NTG-branch) per week. Due to the different preconditions, the different branches are evaluated separately.

For this study, twelve lessons on electric circuit teaching were conceptualised [4][5]. The materials are based on the *Frankfurter Unterrichtskonzeption zum Elektronengasmodell* [2] and comprise explanation videos, interactive screen experiments, exercises, interactive exercises for self-assessment, instructions for pupil experiments and other informational texts.

The teachers participating in the study were categorised in three groups. In group ‘G1_flip‘, the teachers implemented the new teaching design applying the flipped classroom method (n=1116 pupils). In group ‘G2_trad‘ (n=642 pupils) teachers used the same materials but taught a traditional way. Teachers of the control group ‘G3_cont’ (n= 420) taught their pupils without methodological instructions and without the newly conceptualised materials.

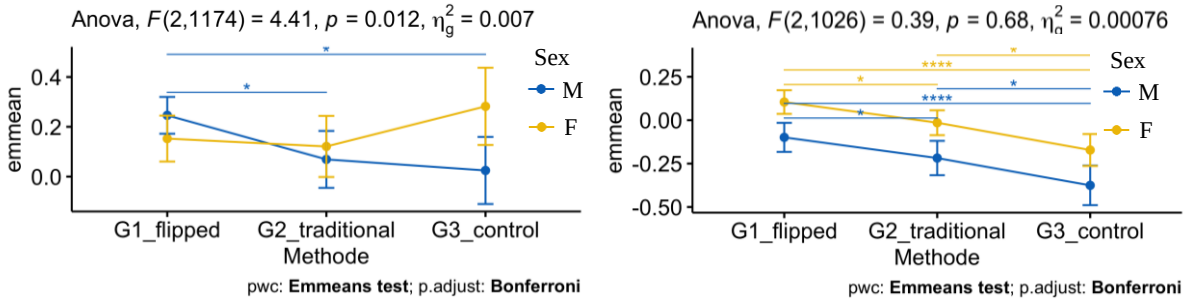
The conceptual understanding of the pupils of ‘electric circuits’ was evaluated in a pre-post-design using the test instrument by Urban-Woldron and Hopf [6]. The physics-related self-concept and the interest in physics were taken as control variables with four items each of the adapted

instrument by Habig [7]. Using IRT-scaling, the learners' abilities were estimated in a longitudinal 2pl model with the package 'tam' using the software R. ANCOVAs were calculated to compare the three groups considering the covariates preknowledge, SC and Int measured in the pretest.

Results

In the NTG-branch, there was a significant interaction between gender and group $F(2, 1174) = 4.41$, $p = 0.012$. To analyse the main effects, the significance levels received a Bonferroni correction and were thus set as $p < 0.025$ for gender and $p < 0.0167$ for group. A significant difference could only be measured for gender in group G3_cont ($p = 0.005$). While the conceptual understanding of the male pupils of the three groups varies considerably ($p = 0.006$), there is no difference for the female pupils ($p = 0.229$). There was a significant statistical difference with the male pupils for the adjusted mean values of the groups G1_flip and G2_trad ($p=0.0317$) and the groups G1_flip and G3_cont ($p = 0.0142$).

In the non-NTG-branch, there is no interaction between gender and group $F(2, 1026) = 0.39$, $p = 0.675$). Yet, there are main effects for gender ($p < 0.025$) and for group ($p <0.0167$). A pairwise comparison of the adjusted mean values yielded significant differences between the groups (G1_flip:G2_trad, $p = 0.0114$) | G1_flip:G3_cont, $p = 0.000000703$ | G2_trad:G3_cont, $p = 0.00650$)



NTG-branch non-NTG-branch

Figure 1. Conceptional understanding grouped by branches

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