The effect of teaching Physics using the Flipped Classroom model on students' domains included in the Integrated Taxonomy

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Abstract. This study examines the effect of the flipped classroom (FC) model on secondary vocational school students through the development of their domains described in the Integrated Taxonomy [1]. This research fills a gap in the Hungarian scientific community having only a few papers written on the FC model examining its effect. Three classes (72 students) participated in the research during Physics classes. This mixed method research study used pre-and post-tests, questionnaires, and quizzes, from which data was collected, processed in SPSS, and quantified with the Wilcoxon signed-rank test. The results showed improvement in each domain in all classes.

Introduction and objective

Since Eric Mazur introduced his "Peer Instruction" method in 1997 to teach university level physics, it has become the root of the now known Flipped Classroom (FC) model [1]. The efficiency of the FC model has been proven to be a useful tool in improving students' learning outcomes in the higher education context [3]. The purpose of this study was to determine the effectiveness of this model by examining students' development on numerous learning domains.

Participants

The group of participants included 72 sixteen- and seventeen-years old students (50 males, 22 females) from three different classes (10A, 10D, 10C) of the same grade in a Hungarian secondary vocational school. The experimental period lasted 2 weeks, through which the classes participated in 4 lessons. The class 10A consists of 29 students (14M, 15F), class 10D consist of 32 students (29M, 3F), and class 10C consists of 11 students (7M, 4F). These students have the same background regarding physics, having learnt it for half of an academic year. Out of the three classes 6 students have learning difficulties being the reason for scaffolded task sheet and tasks with differentiation in difficulty.

Methods

Within the course of the four lessons students learnt the four[1] laws of motion by Newton. In the intervention phase, students were introduced with the basic information about the laws at home using videos uploaded to EdPuzzle that allowed the teacher to embed questions to them. At school, students' knowledge was both broadened and corrected using a Kahoot game. All the lessons included tasks, scaffolded task sheets, task sheets for simulation, group work, etc. to extend their Foundational knowledge and higher-order thinking skills.

To improve their other learning domains (affective, human dimension, learning to learn) the form of learning was mainly group work or pair work. Students opted for working in groups

[1] The hungarian education system considers the law of independence of forces to be an extra, fourth law of motion

or pairs due to the nature of the task sheet which ensured and forced cooperation and collaboration to achieve a common goal.

This mixed research method study included pre-, and post-tests called ConcepTest [1], pre- and post-questionnaires (Sociometry, R-SPQ-2F, PMQ-II), in-class quizzes, and activities (Kahoot, EdPuzzle, MentiMeter, Google Form) from which data were collected. All qualitative data were categorized to make it quantifiable and thus comparable. Certain students or classes chose to fill in the forms and questionnaires anonymously thus making it impossible to assign a state number of certain learning domains to particular classes. In these cases, comparisons were made across the three examined classes.

Data were analyzed using SPSS, quantified, and examined with the Wilcoxon single-ranked test. After the experimental period data were analyzed and interpreted through the lens of domains included in the Integrated Taxonomy [2]. The Integrated Taxonomy (IT) was introduced by Roehling [2] by merging two already existing taxonomies together, Bloom's and Fink's taxonomy. This IT includes the following learning domains through which students' development was followed and compared: Foundational knowledge, higher-order thinking, academic and professional skills, affective, human dimension, learning to learn.

Results

Pre- and post-measurements made it possible to compare the state of the students' learning domains, to which the quantified in-class measurements contributed. By comparing these data in SPSS with Wilcoxon single-ranked test a positive change can be seen across all learning domains. Significant positive changes were recorded in the following learning domains: Foundational knowledge (10D, 10C), Higher-order thinking skills (10A, 10C, 10D), Human dimension (10A, 10C, 10D). In the following cases, only a non-significant positive change was measured: Foundational knowledge (10A), Affective (10A, 10C, 10D), Learning to learn (10A, 10C, 10D).

Conclusions

The FC model was successful in improving learning outcomes and other domains of students; thus, it can be a useful tool in teaching Physics in the Hungarian secondary school context. Improvements can be made by reducing the tools and platforms of teaching to lighten the burden of both learning and teaching.

References

[1] E. Mazur, *Peer Instruction: A User's Manual,* Physics Today, 1997.
[2] P. Roehling, *Flipping the College Classroom*, Springer International Publishing, 2018.
[3] Y. Sun, X. Zhao, X. Li, F. Yu, Effectiveness of the Flipped Classroom on Self-Efficacy among Students: A Meta-Analysis, Cogent Education **10** (2023).