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INVESTIGATING THE POTENTIAL OF THE FLIPPED CLASSROOM MODEL IN K-12 MATHEMATICS TEACHING AND LEARNING

Maria Katsa[1,2], Stylianos Sergis[2], Demetrios G. Sampson[2,3]
[1] *2nd High School of Peristeri, Athens, Greece*
[2] *Department of Digital Systems, University of Piraeus, Greece*
[3] *School of Education, Curtin University, Australia*

ABSTRACT

The Flipped Classroom model (FCM) is a promising blended educational innovation aiming to improve the teaching and learning practice in various subject domains and educational levels. However, despite this encouraging evidence, research on the explicit benefits of the FCM on K-12 Mathematics education is still scarce and, in some cases, even inconclusive. Thus, the contribution of this paper is to present an action research for investigating the impact of FCM in K-12 Math (Algebra) teaching and learning in order to support and extend the narrow existing pool of works. The action research was based on a quasi-experimental design (using an experimental-control group protocol), with a sample of 40 students, for a full semester of the school year. The results provide evidence for potential advantages in students' cognitive learning outcomes (on knowledge of subject domain), students' level of motivation, as well as better use of teaching time during the face-to-face school-based sessions.

KEYWORDS

Flipped classroom model, K-12 Mathematics Education, student learning outcomes, student motivation, teaching time, curriculum teaching

1. INTRODUCTION

Science, Technology, Engineering and Mathematics (STEM) education is recognized as a top global priority (Johnson et al., 2013). Currently, STEM education, and Mathematics in particular, has received attention aiming to promote the use of student-centred teaching approaches (such as the problem-based approach) for cultivating students' problem solving competences in the context of identifying and solving real-world problems (Freeman et al., 2015). This is an important challenge, given that students will be expected to contribute with innovative solutions to ill-defined problems throughout their professional life.

Furthermore, educational innovations (e.g., the Flipped Classroom Model - FCM) have been proposed as a means of enhancing student-centered teaching approaches, and deliver better students' learning experiences and competence development. More specifically, the FCM has been employed to maximize the delivery of hands-on activities and individual scaffolding during the face-to-face sessions, which are supported by the teacher. To deliver this, the model argues for replacing teachers' lecture during the classroom sessions, with appropriately designed learning materials which can be studied by the students at home, in a more self-paced manner (Bergmann & Sams, 2012).

The FCM has attracted a growing level of research attention, globally. This is based on the existing findings which highlight its capacity to improve teaching practice and lead to (among others) better students' cognitive learning outcomes and level of motivation in diverse subjects and educational levels, including STEM (Giannakos et al., 2014; Sahin et al., 2015). Despite this promise, however, the existing evidence of the impact of the FCM on K-12 Math education is still scarce and the findings from these works are not yet conclusively in favor of the FCM (e.g., Clark, 2015). Furthermore, the existing works have primarily focused on studying the impact of the FCM from the perspective of students' learning experiences (i.e., cognitive learning outcomes and motivation), but have not yet explicitly addressed the potential impact on the actual teaching and learning process, in terms of the (re)distribution of learning activities types that are delivered in face-to-face school-based sessions. The latter is a significant shortcoming, since the main standpoint of the FCM is based on its capacity to re-distribute the types of learning activities, by minimizing teacher lecture and increasing students' active learning, collaboration and scaffolding.

Based on the above, the contribution of this paper is to strengthen and extend the existing narrow evidence pool of FCM in the field of K-12 Math (Algebra) education. More specifically, the paper reports a case study of using action research to evaluate the FCM in terms of its capacity to (a) provide additional evidence of the impact of the FCM, in terms of improving students' cognitive learning outcomes and motivation and (b) investigate the impact of the FCM on altering the teaching and learning processes in face-to-face sessions (focusing on the distribution of learning activities types in face-to-face sessions).

The remainder of this paper is structured as follows. Section 2 presents the FCM and existing research works. Section 3 presents the design and implementation methodology of the action research. Section 4 presents the findings for each of the defined research questions. Finally, Section 5 discusses conclusions and potential areas for further research.

2. BACKGROUND

The Flipped Classroom Model (FCM) is a blended learning model, which aims to facilitate teachers make better use of the face-to-face sessions through minimizing teacher lecture and increasing students' active learning, collaboration and scaffolding (Bergmann & Sams, 2012). The rationale behind the FCM is that students can be provided with unique learning experiences during face-to-face sessions, by engaging in collaborative activities with their classmates as well as receiving scaffolding by the teacher (DeLozier & Rhodes, 2016). Capitalizing on this, the FCM promotes the standpoint that lectures can be replaced by appropriate learning materials (e.g., educational videos), which students can study during their "home time" before the face-to-face, school-based sessions (Chen et al., 2014). Thus, more face-to-face time can be invested on authentic learning activities for better engaging students.

The FCM has attracted a growing level of research attention, spanning a large range of subject domains and educational levels (Bishop & Verleger, 2013). Despite this emerging focus, however, research on the subject domain of K-12 Mathematics is still scarce and inconclusive in terms of the actual benefits of the FCM to improve students' learning experiences. More specifically, Bhagat et al. (2016) investigated the potential of FCM to improve the cognitive learning outcomes and motivation of students. Based on the results of a quasi-experimental study, the authors argued that the FCM was beneficial for improving both aspects of students' learning experience compared to a control group. Reyes-Lozano et al., (2014) studied the impact of FCM on students' cognitive learning outcomes and reported that it offered a statistically significant improvement compared to a control group (non-flipped). Finally, Muir & Geiger (2016) explicitly investigated the potential of FCM to improve students' motivation. Using interviews and observations, they concluded that the FCM was beneficial for improving students' motivation in a statistically significant manner compared to a control group. On the other hand, Clark (2015) reported that the FCM was beneficial for improving students' motivation (and attitudes) compared to a control group, however no statistically significant evidence of improvement was evident in terms of cognitive learning outcomes.

Overall, the existing works highlight a dearth of actual evidence on the impact of FCM in K-12 Math teaching and learning, given that (a) the research works that explicitly address this field are still few and (b) the findings from these works, while showing a pattern that supports the capacity of the FCM to improve students' cognitive learning outcomes and motivation, are not yet conclusive. Furthermore, the existing works have primarily focused on studying the impact of the FCM on *students' learning experiences* (including cognitive learning outcomes and motivation), but have not yet explicitly addressed the potential impact on the actual *teaching and learning process*, namely in terms of the (re)distribution the types of learning activities that are delivered in the face-to-face sessions. The latter is a significant shortcoming, since the main standpoint of the FCM is based on its capacity to re-distribute the types of learning activities conducted in face-to-face sessions, namely to minimize the teacher's lecture and increase students' active learning, collaboration and scaffolding. Therefore, it is worthy to investigate whether the adoption of FCM actually delivers this promise to increase the student-engaging learning activities conducted in face-to-face sessions.

In this context, this paper reports the results of a quasi-experimental action research study and provides additional evidence on the impact of FCM on K-12 Math (Algebra) teaching and learning. The contribution of this work is twofold, namely (a) it provides additional evidence to support the currently inconclusive benefits of the FCM to improve students' cognitive learning outcomes and motivation and (b) it investigates the impact of the FCM on altering the teaching and learning processes in face-to-face sessions (focusing on the distribution of different learning activity types). The following section outlines the research methodology of the study.

3. RESEARCH METHODOLOGY

3.1 Action Research

Action research is a reflective process that engages a practitioner to investigate, analyze and improve their practice based on the collection, analysis and interpretation of educational data (Cohen et al., 2007). For the context of this study, the action research was designed to investigate the impact of the FCM model on improving the teaching practice and learning experiences of students in K-12 Algebra. The action research was designed using the model of Lewin (1948), which defines four consecutive phases. More precisely, these phases are the *Plan* phase, the *Act* phase, the *Observe* phase and the *Reflect* phase. During the **Plan phase,** the action research questions, the methodology to be followed as well as the evaluation protocol for assessing impact were defined. Moreover, during this phase, the Algebra course was designed and the learning materials were developed. The **Act** phase consisted of implementing the action research, whereas the **Observe** phase focused on monitoring the implementation of the action research and collecting students' educational data. Finally, during the **Reflect** phase, the analysis of the collected educational data was performed. Based on these analyses, the defined research questions were addressed. Further details on how each phase was implemented, are provided in the following sections of the paper.

Regarding the protocol for study trustworthiness, the work of Shenton (2004) was employed for outlining the following criteria:

- **Credibility (internal validity)** and **Confirmability (objectivity)**. The study (a) utilized robust and widely used methodologies and data collection and analysis tools, (b) employed various sources for collecting and analyzing educational data (triangulation), (c) adopted a protocol of peer-scrutiny throughout the action research and, finally, (d) was designed, implemented and evaluated by strictly considering and extending the current research state-of-the-art.
- **Transferability (external validity)**. The study (a) presented and discussed the design elements, including duration and context of application, sample size, sample data related to characteristics and between-group comparison, tools for data collection and analysis, and (b) outlined a set of study limitations, in order to promote and feed future research in this field.
- **Dependability (reliability).** The study (a) formulated and clearly presented both the design as well as the implementation methodology and processes, (b) formulated and clearly presented all methods for data collection and analysis and (c) defined specific Research Questions and reported the analysis of educational data for evaluating and addressing each of them.

3.2 Research Questions

Based on the analysis of the research state-of-the-art, three research questions were defined, as follows:

- **Research Question 1**: Does the FCM impact students' cognitive learning outcomes compared to a control group, in a high school Algebra course?
- **Research Question 2**: Does the FCM impact students' level of motivation compared to a control group, in a high school Algebra course?
- **Research Question 3:** Does the FCM affect how the learning activity types are distributed in the face-to-face school-based sessions compared to a control group, in a high school Algebra course?

3.3 Context and Participants of Study

The study was implemented over a period of 8 weeks (a full school semester). The context of the study was the 2nd grade of High School Algebra within the Greek National Curriculum (ages 16-17). The course used in the action research covered the concepts and applications related to functions, matrix manipulation (e.g., determinants, eigenvalues and eigenvectors) as well as designing and manipulating function plots. The action research utilized two student classes, with a total of 40 students. One class acted as the experimental group which attended the FCM-enhanced Algebra course and the other as the control group, which attended the non-FCM Algebra course. Both student groups comprised 20 students, with a similar distribution of 8 boys and 12 girls.

Prior to the study, the researchers acquired consent by (a) the school leader and the Ministry of Education, as well as (b) the parents of all the students included in the sample. Moreover, all students were made aware that their participation was voluntary and they could quit the study at any time. Lastly, all student-related educational data collected were fully anonymized.

3.4 Procedure

The first phase (**Plan phase**) of the study was implemented over a three-month period (June 2013 to August 2013). During this phase (a) the action research methodology was defined and (b) the educational design of the Algebra course (for both student groups) was formulated. Furthermore, for the experimental group, during the Plan phase the additional learning materials were developed and/or selected. These materials were provided to students for their home-based study. Finally, the online classroom environment (based on Moodle Learning Management System [https://moodle.org]) was developed. The online classroom environment was used for hosting and delivering the learning activities beyond the physical classroom for the experimental group.

To reduce result bias, the two instances of the Algebra course (namely, the experimental and the control instance) were designed with the highest level of similarity in the educational design elements. For both instances of the course, the **teaching approach** adopted was a problem-based approach, which engaged students in collaboratively defining and solving well-/ and ill-defined problems related to each unit of the course. Additionally, both groups exploited the following **teaching techniques**: (a) the *Jigsaw* technique, for promoting active student collaboration during the problem-solving process, (b) the *Think-Pair-Share* technique, for promoting students' collaboration on solving a specific problem and (c) the *Brainstorming* technique (individually and with peers), in order to engage students in defining potential solutions for both well-/ and ill-defined problems. The **assessment methods** for both groups comprised: (a) written assessment tests, which contributed to their final grade, and (b) collaborative project implementation. Finally, both student groups aimed to attain the same educational objectives and had the same frequency and duration of face-to-face sessions.

Regarding the differences in the design and delivery between the two student groups, these comprised variations in the distribution of learning activities occurring in the face-to-face sessions and the 'home-based' sessions. More specifically, for the *control group*, the weekly flow of learning activities was as follows. Initially, during the face-to-face session, the teacher presented the new learning material/concepts, before all other learning activities. During the remaining face-to-face time, students engaged in (collaborative) problem-based activities. After each face-to-face session, the teacher assigned homework. Regarding the *experimental group*, the weekly flow of learning activities included a pre-session (hosted in Moodle at home), in which the students studied learning materials (mainly educational videos) provided by the teacher and engaged in self-assessment through quizzes. This aimed to introduce students to the basic concepts that would be addressed in the upcoming face-to-face session, so that the latter could be directed on the (collaborative) problem-based activities and scaffolding/feedback provision.

After the Plan phase was completed, the **Act phase** and the **Observe phase** were implemented. They were both aligned to the delivery of the educational design (8 school weeks). The *Observe phase* employed a range of data collection methods and instruments, which are presented in detail in the following section. Finally, the **Reflect phase** was conducted. This final phase lasted two months and was addressed on analyzing and interpreting the data which were collected during the previous phases, in order to answer the defined Research Questions. The data analysis methods and tools for implementing the *Reflect phase* are discussed in detail in the following section.

3.5 Instruments and Data Analysis

For the purpose of the Observe and Reflect phases of the study, triangulation of findings was performed by collecting data from various and diverse sources (Phillips & Carr, 2010). Regarding instrument validity, content validity and construct validity were achieved by (a) the practitioner and (b) a group of 'external reviewers', comprising the 'critical friend' of the practitioner (discussed below) and the researchers (other authors), who are experts in educational research and educational technologies. Additionally, this groups of external reviewers supported the practitioner in (a) the process of data sense-making (e.g., data from the journal observations or surveys) and (b) the process of interpreting the results of the data analysis in order to address the defined Research Questions.

Regarding data collection for Research Question 1, the students' cognitive learning outcomes were assessed via four assessment tests. These assessment tests were common for both student groups and comprised an initial diagnostic test and three standardized tests for assessing students' cognitive learning outcomes.

The diagnostic test was delivered before the action research was initiated, so as to assess students' prior knowledge on Algebra, from the previous grades. The test comprised both closed (e.g., MCQ) and open-ended (e.g., short answer) questions. Building on the results of the diagnostic test, each student group was divided in three clusters, based on their performance. The clusters (Table 1) were low performers, medium performers and high performers. This student clustering was exploited during the process of data analysis, so as to investigate how the FCM had affected each performance-based cluster.

Table 1. Student performance clusters based on diagnostic test

Performance Categories	**Group Size (N)**	
	Control group	**Experimental group**
Low Performers	7	7
Medium Performers	7	8
High Performers	6	5

The remaining three tests were delivered after the end of (a) the third week, (b) the sixth week and (c) the eighth week. All tests were graded in a 20-point scale, following Greek National Curriculum standards.

The **data analysis methods for Research Question 1** comprised paired-sample and independent sample t-tests tests based on students' assessment scores across the two groups. Furthermore, descriptive statistics analysis was employed so as to investigate the impact of the FCM on the within-group, performance-based clusters (i.e., low-medium-high performers).

Regarding **data collection for Research Question 2**, the Instructional Materials Motivation Survey (IMMS) questionnaire was used for assessing students' level of motivation (Keller, 2010). The IMMS questionnaire adopts the ARCS motivation model and defines four dimensions of motivation, i.e., Attention, Relevance, Confidence and Satisfaction. For the context of this study, the IMMS questionnaire was re-evaluated in terms of internal consistency reliability using the Cronbach's alpha coefficient ($0.895 < \alpha < 0.946$ for the four dimensions; $\alpha=0.95$ for the overall instrument).

The **data analysis methods for Research Question 2** comprised independent sample t-tests, to highlight any statistically significant differences in the level of motivation between the two student groups.

Regarding **data collection for Research Question 3**, the study employed the commonly used teacher journal technique (Altrichter et al., 2008). The aim of the teacher journal was to record the specific learning and assessment activity types being delivered during the face-to-face sessions. For the scope of this study, a custom typology was used, comprising five activity types: *teacher lecture*; *student-student collaboration*; *student-teacher interactions*; *'hands-on' competence-building activities*; and *assessment activities* (i.e., standardized tests and formative assessment). Finally, the teacher journal was also enriched by the practitioners' observations. This task was supported by the observations of a 'critical friend', who was a senior peer practitioner, facilitating the implementation of the action research.

The **data analysis methods for Research Question 3** comprised descriptive statistics analysis to elicit whether, and to what extent, the face-to-face sessions of the experimental group comprised of different learning activity types compared to the control group. More specifically, the time spent on each learning activity type was recorded and codified for each face-to-face.

The IBM "Statistical Package for the Social Sciences" (SPSS) version 22 for Windows was used for conducting all data analyses.

4. RESULTS

4.1 Results for Students' Cognitive Learning Outcomes (Research Question 1)

The Research Question 1 investigated the impact of the FCM on students' cognitive learning outcomes. Table 2 depicts the analysis results regarding the mean values of students' assessment tests, for each student group. Levene's test for equality of variances showed equal group variances for all cases.

Table 2. Analysis of standardized assessment scores of the control and experimental groups (t-test)

Standardized Assessment Tests	**Mean (*SD*)**		**t (*df*)**	**p**
	Control group [N=20]	**Experimental group [N=20]**		
Diagnostic Test	13.2 *(3.83)*	13.3 *(3.84)*	-.082 (*38*)	.935
Assessment Test #1	14.5 (*3.57)*	15.2 *(3.22)*	-0.650 *(38)*	.520
Assessment Test #2	14.7 (*3.11)*	16.3 (2.*36)*	-1.830 *(38)*	<0.05
Assessment Test #3	14.7 (*3.29)*	17.2 (2.*08)*	-2.866 *(38)*	<0.05

As the Table 2 depicts, the two groups show non-significant differences in the assessment scores for the diagnostic test, therefore their prior knowledge is considered similar. Regarding assessment test #1, the groups show a statistically non-significant difference, however an increase of 1.9 points for the experimental group (compared to 1.3 of the control group) is evident. Regarding assessment tests #2 and #3, there is a statistically significant improvement of the experimental group.

Furthermore, the improvement of both groups was explicitly studied, by considering their improvement between the diagnostic and the assessment test #3 results. The results of the paired-samples t-tests showed that both groups improved their cognitive learning outcomes in a statistically significant manner, i.e., the experimental group (t(*df*) = -8.658(*19*); p<0.00) and control group (t(*df*) = -4.626(*19*), p<0.00). This provides with evidence that the non-FCM Algebra course instance (which was delivered to the control group) also effectively enhanced the students' cognitive learning outcomes. Therefore, this argues that the statistically significant improvement of the experimental group can be attributed to the FCM.

Finally, the data for the experimental group were also analysed in terms of the within-group clusters. The results of this analysis are depicted in Figure 1, and refer to the rate of improvement between the initial diagnostic test and the final assessment test #3.

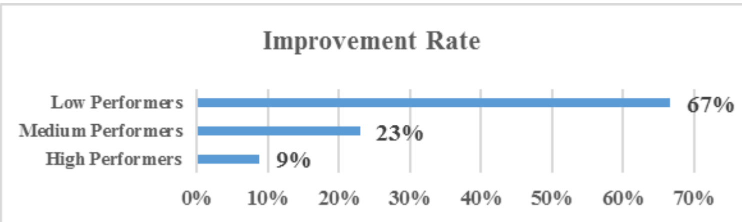

Figure 1. Rate of improvement in assessment scores for each performance-based cluster

As Figure 1 depicts, the low-performing cluster showed the largest ratio of improvement (67%), compared to the medium performing cluster (23%) and the high performing cluster (9%). This provides useful evidence of the potential benefits of the FCM for students facing difficulties. This highly promising potential is, therefore, worthy to be examined further.

4.2 Results for Students' Motivation (Research Question 2)

The Research Question 2 investigated the impact of the FCM on students' level of motivation. Table 3 depicts the analysis results in terms of the four dimensions defined in the IMMS questionnaire.

Table 3. Analysis of motivation level between the control and experimental groups (t-test)

Motivation Dimension	**Mean (*SD*)**		**t (*df*)**	**p**
	Control group [N=20]	**Experimental group [N=20]**		
Attention	3.65 *(.54)*	4.31 *(0.47)*	-4.077 *(38)*	<0.01
Relevance	3.50 *(0.64)*	4.27 *(0.48)*	-4.319 *(38)*	<0.01
Confidence	3.76 *(0.53)*	4.32 *(0.43)*	-3.692 *(38)*	<0.01
Satisfaction	3.71 *(0.55)*	4.37 *(0.34)*	-4.574 *(38)*	<0.01

As the Table 3 depicts, the experimental group showed a consistent pattern of higher levels of motivation compared to the control group. Based on this evidence, it is argued that the FCM was beneficial for building the students' *Satisfaction* for the course, as well as to support them in better conceptualizing the content and concepts delivered. Furthermore, students in the experimental group grew more confident in participating and completing the learning activities of the course (*Confidence* dimension) and were more highly intrigued by the course (*Attention* dimension). Finally, evidence shows that the FCM facilitated students to sustain a higher level of interest for the Math course and render it more relevant to the students' own interests (*Relevance* dimension).

4.3 Results for the Distribution of Types of Learning Activities in Face-To-Face Sessions (Research Question 3)

The Research Question 3 investigated the impact of the FCM on altering the distributions of learning activity types being delivered in the face-to-face sessions. Figure 2 presents the results, depicted as the mean value for all 8 weeks of the study.

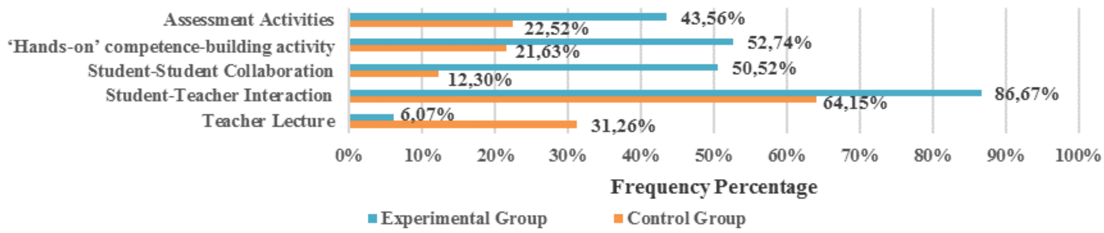

Figure 2. Frequency percentages of learning and/or assessment activity types during face-to-face sessions

As Figure 2 depicts, regarding the **control group**, teachers' lecture was the main type of learning activity for the control group, since all learning content was delivered by the teacher, in-class. A significant portion of teaching time was invested in student-teacher interactions and 'hands-on' activities. This can be attributed to the student-centered teaching techniques employed (namely, problem-based approaches). On the other hand, student-student collaboration was performed infrequently, which is considered a significant shortcoming. Lastly, assessment activities primarily referred to standardized assessment tests. Regarding the **experimental group**, the largest portion of teaching time was invested on student-student collaboration and student-teacher interactions. This finding provides explicit evidence to support the potential of FCM to allow teachers make better use of their teaching time. Lastly, 'hands-on' activities were also very frequently delivered, as was the provision of formative assessment and feedback (which complemented the standardized tests).

5. DISCUSSION AND FUTURE WORK

The paper presented a case study for investigating the impact of the FCM on K-12 Math (Algebra) education. Based on a literature review, three research questions were defined in order (a) to extend the existing narrow evidence pool on the effects of the FCM in K-12 Math teaching and learning, in terms of enhancing students' cognitive learning outcomes and motivation, and (b) to investigate whether the adoption of the FCM actually facilitated the teacher to alter the focus of the face-to-face sessions. The insights from the action research provide promising evidence of the potential of the FCM model to:

- Improve the cognitive learning outcomes of students, in a statistically significant manner. This finding is consistent with previous works (e.g., Bhagat et al., 2016; Reyes-Lozano et al., 2014) and adds additional evidence to the currently inconclusive and narrow literature.
- Provide the most benefit for improving the cognitive learning outcomes in the case of low-performing students. This benefit can be attributed to the availability of scaffolding in face-to-face sessions and corroborates the results of Bhagat et al. (2016), creating a pattern of similar results.
- Maximize classroom time invested on collaborative, hands-on activities. Based on this evidence, the FCM can provides a potentially effective means for teachers in order to promote more engaging approaches to K-12 Math teaching and learning (e.g., problem-based or project-based approaches).

Future work should aim to extend the findings of this study, by investigating the effect of FCM on different aspects of students' learning experiences and competences in Math, such as creative and collaborative problem solving skills. Furthermore, more longitudinal qualitative approaches should be designed to further explore the effects of the FCM over a wider span of time and from a more diverse set of learning experience aspects (e.g., level of engagement or behavioural analysis). Finally, insights from these studies can also utilize the state-of-the-art in the emerging field of Teaching and Learning Analytics (Sergis & Sampson, 2016), so as to support teachers to reflect on their teaching practice in a data-driven manner.

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REFERENCES

Altrichter, H., et al., 2008. *Teachers investigate their work: An introduction to action research across the professions (2nd Edition)*. Routledge, New York, USA.

Bergmann, J., and Sams, A., 2012. *Flip your classroom: Reach every student in every class every day*. International Society for Technology in Education, Washington, USA.

Bhagat, K.K., Chang, C.N., and Chang, C.Y., 2016. The Impact of the Flipped Classroom on Mathematics Concept Learning in High School. *Educational Technology & Society*, Vol. 19, No. 3, pp. 124–132.

Bishop, J.L., and Verleger, M.A., 2013. The flipped classroom: A survey of the research. In *Proceedings of the 120th ASEE National Conference* Atlanta, USA, pp.1-18.

Chen, Y., et al., 2014. Is FLIP enough? Or should we use the FLIPPED model instead? *Computers & Education*, Vol. 79, pp. 16-27.

Clark, K.R. 2015. The Effects of the Flipped Model of Instruction on Student Engagement and Performance in the Secondary Mathematics Classroom. *Journal of Educators Online*, Vol. 12, No. 1, pp. 91-115.

Cohen, L., Manion, L., and Morrison, K., 2007. *Research Methods in Education (6th Ed.)*. Routledge, New York, USA.

DeLozier, S.J., and Rhodes, M.G., 2016. Flipped Classrooms: A Review of Key Ideas and Recommendations for Practice. *Educational Psychology Review*, (*Early-view*).

Freeman, B., Marginson, S., and Tytler, R., 2015. Widening and Deepening the STEM Effect. *The Age of STEM: Policy and practice in science, technology, engineering and mathematics across the world*, pp. 1 - 21, Routledge, NY, USA.

Giannakos, M.N., Krogstie, J., and Chrisochoides, N., 2014. Reviewing the flipped classroom research: Reflections for computer science education. *Proceedings of the Computer Science Education Research Conference*, Berlin, Germany, pp. 23-29.

Johnson, L., et al., 2013. *Technology Outlook for STEM+ Education 2013-2018: An NMC Horizon Project Analysis*.

Keller, J.M. (Ed) (2010). *Motivational design for learning and performance: The ARCS Model Approach*. Springer, US.

Lewin, K., 1948. *Resolving social conflicts; selected papers on group dynamics*. Harper & Row, New York, USA.

Muir, T., and Geiger, V., 2016. The affordances of using a flipped classroom approach in the teaching of mathematics: a case study of a grade 10 mathematics class. *Mathematics Education Research Journal*, Vol. 28, No. 1, pp. 149-171.

Phillips, D. and Carr, K., 2010. *Becoming a teacher through action research: Process, context, and self-study*. Routledge, New York, USA.

Reyes-Lozano, C.A., et al., 2014. Flipped Classroom as Educational Technique To Teach Math On A Competencies-Based Approach: Case Study. *Proceedings of the Latin American Conference on Learning Objects and Technologies*, Colombia, pp. 166-176.

Sahin, A., Cavlazoglu, B., and Zeytuncu, Y.E., 2015. Flipping a college calculus course: A case study. *Educational Technology & Society*, Vol. 18, No. 3, pp. 142-152.

Sergis, S., and Sampson, D. 2016. Towards a Teaching Analytics Tool for supporting reflective educational (re)design in Inquiry-based STEM Education. *Proceedings of the 16th IEEE International Conference on Advanced Learning Technologies*. Austin, USA.

Shenton, A.K., 2004. Strategies for ensuring trustworthiness in qualitative research projects. *Education For Information*, Vol. 22, No. 2, pp. 63-75.