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Effects of the flipped learning approach on students' academic achievement in secondary schools in Kenya.

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Abstract
In most secondary schools, the conventional approaches to learning are exclusively used for science education, though with mixed results. These conventional learning approaches do not arouse the learner's interest in science or improve learners' cognitive development. The rise in new pedagogical approaches has seen the adoption of flipped learning approaches take a focal point in improving cognitive development and achievement outcomes in science education in secondary schools and university levels alike. Thus, the study adopted the flipped learning approached and used the Solomon four non-equivalent control group to explore the possibility of using flipped classroom arrangement with the aid of a computer-based collaborative concept mapping to foster meaningful learning and creativity in Biology instruction in secondary schools in Kenya. In the study, 345 form-two students were enrolled and were randomly split as a whole class into the intervention (flipped learning approach) or control (conventional teaching method) groups who were taught separately. The study was located in eight extra-county schools in Uasin Gishu County, Kenya drawn from because the school are well-equipped with computing facilities for learning. Both groups were taught the respiration concepts, with the experimental group ($n = 167$) being taught with the aid of computer-based concept mapping outside the normal class hours (5.00 pm - 6.00 pm) in the computer laboratory while the control group ($n = 178$) was taught within their respective class hours. The whole concept of respiration was taught in five lessons each lasting for one hour daily over a period of five days (300 minutes). Before the commencement of the experiment, the study carried out an initial examination of attitudes and test scores. The t-test results that the initial attitudes towards biology for the two groups were equivalent ($t = -0.820$, $p > 0.05$) while the initial biology score before the experiment were equivalent ($t = -1.463$, $p > 0.05$). The study used descriptive statistics and the independent t-test to test for any differences at 0.05 significance levels. The results indicate that there were significant gender differences in the scores for the study group ($t = -2.740$, $p < 0.05$) and experimental groups ($t = -4.819$, $p < 0.05$) after the experiment. In testing for the control, there were no significant differences in the scores for the control groups ($t = -1.463$, $p > 0.05$) before the experiment, but, there were significant differences in the scores for the experimental groups ($t = -4.819$, $p < 0.05$) after the experiment. However, there were significant differences in the scores for the control group ($t = -2.299$, $p < 0.05$) after the experiment. Findings revealed that academic achievement was significantly higher in the intervention group than those in the conventional group. Based on the findings, the study concluded that computer-based collaborative concept mapping explains the gender and group differences in the post-test scores. This implies that flipped learning approach could improve students' attitudes of students towards biology, thereby improving their academic achievement. The result is especially relevant to learning science in secondary and tertiary institutions in sub-Saharan Africa. The study recommends that teachers adopt the most realistic learning approaches that may positively influence attitudes and achievement in science education.

Key Words: *Flipped learning approach, collaborative learning, Concept mapping, Mindtools, academic achievement.*

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I. Introduction

Student's academic achievement is largely determined by individual factors (Veas *et al.,* 2019; Han*et al.*, 2015) such as the student's cognitive abilities as well as self–discipline (Shi & Qu, 2022; Liang *et al.,* 2020) but is shaped largely by student attitude, classroom instruction and climate, home and community educational contexts, curriculum design and delivery and school demographics and organization in that order (Schneider &Preckel, 2017). At an individual level, academic achievement is also strongly associated with clarity and understandability, the teacher's stimulation of the student's interest, elocutionary skills and the teacher's enthusiasm (Schneider & Preckel, 2017; Nicol & Macfarlane-Dick, 2006).

Students' interest and attitude to learning are the predominant factors in the mastery of any subject matter (Nja *et al.,* 2022) as indicated by the impact of positive attitudes towards science and technology influence science education (Sjøberg& Schreiner, 2010). Thus, academic achievement in science is determined by the learners' experiences, skills, and self-regulation as different cognitive learning strategies are deployed in a distinct learning context, whether in the classroom or laboratory (Aquino & Bautista, 2022; Nja *et al.,* 2022). Further, student perceptions of their cognitive learning practices are influenced by colleagues and teachers alike (Discipulo & Bautista, 2022). As observed by Potvin and Hasni (2014) and Shute and Rahimi (2017), the interest, motivation and attitudes towards science education significantly decline between elementary and secondary school. For instance, Barmby *et al.,* (2008) observed that students' attitudes towards science in England declined as they progressed through high school and that the decline was more pronounced in female pupils.

This decline has been attributed to the conventional teaching techniques which do not sustain the initial strength of students' attitudes toward sciences (Christidou, 2011). This is further exacerbated by the unattractiveness of current school science as it does not involve interesting topics or provide students with opportunities for creative expression (Christidou, 2011). In the long run, affective learning outcomes are more important to further learning activities than cognitive ones (Savelsbergh *et al.,* 2016; Maltese & Tai, 2011). In biology subject, this attitudinal aspect tends to vary by topic and by gender. But the observation is contrasting as Simonneaux *et al.,* (2005) affirmed that more girls than boys considered science as difficult while Uşak *et al.,* (2009) suggest that biology is more popular among girls than boys. Gender does not seem to affect students' overall views about biology (Soltani& Nasr, 2010).

Academic achievement is also predicted by the students' approaches to learning (García *et al.,* 2016; Schneider &Preckel, 2017) but Science teachers also play a critical role in the formation and reorganization of students' conceptions and attitudes towards science, hence, teachers with a positive view towards science tend to draw a comparative positive view among students (Nja *et al.,* 2022; Potvin &Hasni, 2014). However, the effectiveness of teaching methods depends on their implementation. It is not only what teachers do on the micro-level but also how exactly they do it, that critically affects achievement (Nicol & Macfarlane-Dick, 2006). Even though schools facilitate equal classroom instruction for all students, a wide range of differences is observed in achievement outcomes because of several related factors (Richardson *et al.,* 2012; Han*et al.,* 2015). Therefore, the promotion of students' creative potential through creative thinking instruction is important in the current education system (Wu *et al.,* 2013).

Every student has intrinsic cognitive abilities but not every other student can develop higher cognitive abilities because the existing education system does not provide an effective learning environment for the development of creativity (Wu *et al.,* 2013). This is so because the application of conventional teaching techniques may only involve the inculcation of knowledge and not the development of knowledge structures. Therefore, it is critical that the teacher examines the students' future career aspirations in the academic and professional disciplined and seeks ways and means to realign the student's cognitive abilities to suit their career aspirations (Nja *et al.,* 2017).

Barring the challenges of the current education systems, the 21st century has seen a paradigm shift from teacher-centred orientation to learner-centred orientation because of the learning concerns attributable to conventional teaching techniques. The surge in innovative learning techniques which situates learning on an interactive medium has further ensured the shift (Nja *et al.,* 2022). Scholars in the education sector have indicated that the technologies used should not only support learning but also aid knowledge construction (Hwang *et al.,*2014). Using technologies in teaching induces a change in pedagogical practice (La Velle *et al.,* 2003; Serin, 2011) as the cognitive tools embedded in ICT and the pedagogical content knowledge provide a powerful driver for knowledge transformation (La Velle *et al.,* 2003).

Different studies indicate that various teaching strategies ranging from inquiry-based, cooperative, project-based and problem-based learning have been adopted as the most effective teaching and learning methods in school (Ayaz & Sekerci, 2015; Aktamis *et al.,* 2016; Schroeder *et al.,* 2007). Effective teaching strategies can be organized into decisions regarding the motivational atmosphere, classroom management, and curriculum and instruction (Allen *et al.,* 2013). However, the combination of teacher-centred and student-centred instructional elements is more effective than either form of instruction alone (Schneider, 2012). Accordingly, a better understanding of learning strategies in the educational process may also help students to modify and improve their strategy use (Ruffing *et al.,* 2015). For instance, Sugano and Nabua (2020) examined the effects of the instructional methodology on academic achievement in chemistry and the findings showed that varied teaching intervention strategies have a significant impact on academic achievement in contrast to the traditional teaching method.

The scientific and technological improvements have significantly impacted science education (Aktamiş *et al.,* 2016). In a study, Sugano and Nabua (2020) observed that manipulative and modelling techniques form the most important teaching methods for examining academic achievement in science education. Interactive technologies such as videos, concept–mapping tools, instructive technologies, and shared learning platforms are used to support and aid in learning (Lag & Sæle, 2019). Several studies suggest that technology is merely a vehicle that would transport content without changing (Kudish *et al.,* 2016; Cimpian *et al.,* 2020) while others have claimed that technology has the potential revolutionized education by availing freely teaching and learning materials, providing quick individualized feedback and helping students to interact (Nicol & Macfarlane-Dick, 2006).

The use of flipped classes is a blend of technology–intermediated learning where learners actively participate in the learning both inside and outside the classroom (Saglam& Arslan, 2018). A flipped classroom involves the teacher initiating active learning through the use of technology–aided learning to actively engage collaboratively and co-operatively (Nja *et al.,* 2022). Flipped learning was pioneered in 2012 by Aeron Sams and John Bergmann who are both high-school chemistry teachers (Birgili *et al.,* 2021). Since its novelty, flipped learning has gained recognition as useful in many disciplines such as engineering, education, mathematics, medicine, law, literature and science (Lin & Hwang, 2019). In the flipped classroom, the teacher uses participation and engagement to attract the learners' attention. In this manner, students in flipped classrooms can constructively participate in cognitive development (Birgili *et al.,* 2021; Kevser, 2021).

Flipped learning is a novel framework within which students access personalized education appropriate for individual learning needs (Birgili *et al.,* 2021). Flipped classroom enhances classroom interaction between the instructor and learners, ensures effective classroom participation, promotes active learner participation and helps the learner develop (McLean &Attardi, 2016). During the flipped classroom setting, self–regulation is encouraged, progressive learning techniques are applied and learning exercises are utilized to further the learning outcomes (Lag & Sæle, 2019). The most common learning approaches in the flipped classroom include collaborative, cooperative, peer-based and inquiry-based learning approaches (Strohmyer, 2016).

Flipped classroom approach recognized individual learner differences, thus improving the learning context and increasing learners' interest in a classroom (Nja *et al.,* 2022) while enhancing students' self-learning and critical thinking as well as building experiences and communication skills (Strohmyer, 2016). Flipped learning allows instructors to modify the traditional classroom environment by introducing course content and basic learning objectives to learners before meeting in class and using class time to guide each student with active learning experiences (Birgili *et al.,* 2021).

Flipped learning cannot be imagined without the use of technology. In every flipped learning approach, technology has to be integrated into teaching and learning activities. The flipped learning approach transforms the classroom into an interactive platform which transforms information into knowledge and experience (Birgili *et al.,* 2021). Flipped learning approach relative ease to integrate systematically into existing teaching and learning systems without the need to rebuild an institution's culture and organizational structure (Hwang *et al.,* 2015).

Flipped learning has several benefits that include tactical learner preparation for the in-class teaching and learning process (Birgili *et al.,* 2021). In this manner, it fosters a more productive learning relationship between teachers and learners (McCarthy, 2016), students pace their learning and are responsible for their learning (Kim *et al.,* 2017). It also confers teachers the opportunity to select from a large pool of learning activities such as cooperative learning, peer instruction, mastery learning, role-playing, and inquiry-based learning (Birgili *et al.,* 2021). flipped learning has a positive effect on students' learning outcomes, success, and/or academic achievement (Tsai *et al.,* 2017).

II. Literature Review

Given that the world is embracing information technology, the study explores the possibility of using flipped classroom arrangement with the aid of a computer-based collaborative concept mapping to foster meaningful learning and creativity in Biology instruction. First, the review focuses on students' attitudes before evaluating the differences in academic achievement in biology based on Solomon's four non-equivalent control groups.

The empirical studies have shown that the usage of concept maps is a meaningful learning technique as it positively influences students' attitudes (Hwang *et al.*, 2011). Sung & Hwang (2013) examined the use of the mindtool-integrated collaborative educational game among students in an elementary school. Sümeyye (2012); Cheema and Mirza (2013), and Hwang *et al.*, (2014) examined the use of concept mapping tools among secondary school students, while Mahasneh (2017) examined the attitudes and achievements of university students majoring in education. The study findings indicated that the experimental groups had comparatively higher attitudinal components than the control groups.

Research on concept mapping as a learning strategy to learn science content is broad and diverse. Within the university context, several studies have examined the application of concept–mapping to the critical thinking of university students. For instance, Chen *et al.*, (2011) carried out an experimental study on nursing students to gauge their critical thinking skills. Kaddoura *et al.*, (2016a); Kaddoura *et al.*, (2016b) examined the development of critical skills among nursing students, while Ullah *et al.*, (2021) qualitatively examined the affective, psychomotor and cognitive domains of university students. These studies revealed that concept mapping improves the critical thinking of the experimental groups.

Youssef & Mansour (2012) and reported that concept mapping improved the learning achievement of university students in Iran. Martínez *et al.*, (2013) evaluated the effectiveness of concept mapping on university students learning physics. Cheng and Chu, (2019) evaluated undergraduate students learning computer science while Liu *et al.*, (2010) examined the effect of a computer-assisted concept mapping learning strategy on the learning achievement of students enrolled in an English proficiency course. The findings indicate that the experimental group had higher learning achievement than the students in the control groups. For example, Wu *et al.*, (2013) examined the different impacts of technological aids such as mobile-based mind tools and computer-based learning tools. The findings showed the experimental group using mobile–based mind tools scored highly in creative performance in a project-based learning task.

The empirical reviews on the concept mapping on learner attitudes show that concept mapping at an individual level (Hwang *et al.*, 2014) and collective level (Youssef & Mansour, 2012; Hwang, Shi & Chu, 2011) has a positive effect on learner attitudes (Nesbit & Adesope, 2006). The studies range from elementary school (Hwang, Shi & Chu, 2011), secondary school (Hwang *et al.*, 2014), university-level (Mahasneh, 2017; Youssef & Mansour, 2012) and were quasi-experimental, qualitative (Ullah *et al.*, 2021) and all indicated the positive effect on the learner attitudes.

The studies on the influence of concept mapping on academic achievement show that concept mapping has a positive effect on critical thinking (Wu *et al.*, 2013; Kaddoura *et al.*, 2016b) and academic achievement (Martínez *et al.*, 2013; Sumeyye, 2012). The studies range from the elementary school level (Cheema & Mirza, 2013) to the university level (Wu *et al.*, 2013; Kaddoura *et al.*, 2016) and were quasi-experimental and all had convergence in findings. These studies were limited in some ways that included the focus of the study and the pedagogic design and this confers the study with an opportunity to examine how collaborative learning with the aid of mindtools (concept mapping) influences students' academic achievement in biology subjects in secondary schools in Uasin Gishu County, Kenya.

III. Problem Statement

Problem statement

Whereas many initiatives relating to school science are driven by a concern to improve students' achievement (Sjøberg & Schreiner, 2010), schools, unfortunately, are not able to preserve the initial strength of students' attitudes toward science (Potvin &Hasni, 2014) in that the conventional approach has failed to prepare students beyond school and to present science as a fascinating, interesting and rewarding subject (La Velle *et al.*, 2003). Various studies have emphasized the adoption of different pedagogical perspectives to address the learning challenges of the twenty-first century (Gutiérrez-Braojos & Salmerón-Pérez, 2015). This scenario has arisen because of the contrasting effects and results, which have raised questions concerning the effectiveness of the varied instructional methodologies on student learning and have raised considerable interest in the field of educational research (Sugano & Nabua, 2020). Based on the foregoing review study postulated that the use of a flipped learning approach based on the use of a computer-based collaborative concept – mapping has a significant effect on the academic achievement of secondary school students in Uasin Gishu County, Kenya.

IV. Material and Methods

The study used the experimental design known as the Solomon four non-equivalent design which involved two assessments at the onset (pre-test) and the end (post-test). A student attitudinal test (SAT) based on

5- Likert type scale was given to both groups to gauge their attitudes towards biology. The groups were assessed based on the biology achievement test (BAT) given at the end of the experiment. The baseline data generated from a student attitude questionnaire and biology achievement test were collected from all participants before the teaching intervention.

The study was located in eight extra-county schools in Uasin Gishu County, Kenya drawn from because the school are well-equipped with computing facilities for learning. The 345 form-two students enrolled in the study were split into either the experimental or control group. This was done by randomly assigning the whole class into the intervention (computer-based concept mapping) or control (conventional teaching method) groups that were taught separately. The concept mapping on respiration concepts in the experimental group was taught outside the normal class hours (5.00 pm-6.00 pm) in the computer laboratory while the control groups were taught within their respective class hours.

The control group (n = 178) were taught in a normal classroom setting by the subject teacher. This process involved the preparation of a lesson plan using the standard teaching pack. All the illustrations of the concepts were done on the board and the books and the teachers sought feedback after the class. The whole concept of respiration was taught in five lessons each lasting for one hour daily over a period of five days (300 minutes). Meanwhile, the experimental group (n = 167) were taught using computer-based concept maps for the first three days over a period of one week. First, the participants in the group were inducted into the use of computing technology before the experiment started. The content for the lesson included CMapTools which were downloaded freely from http://cmap.ihmc.us and loaded into all the personal computers in the computer lab. In the experimental group, the teacher first explained why concept mapping is a useful tool for learning and how concept mapping can be used to show relationships among concepts, and then spent hours training students to draw concept maps under the procedures.

With the aid of the software, the students began by placing the general idea (respiration) at the top of the map. The students then work down the list and added more concepts as needed, each time placing the selected two, three, or four sub-concepts to place under each general concept. The hierarchically linking together a large number of related ideas illustrated the structure of meaning for the given subject domain. The students would then restructure their map, in several ways which included adding, subtracting, or changing superordinate concepts. This process went on indefinitely as an individual or as the group gained new knowledge or new insights.

The data analysis plan was based on the Solomon four non-equivalent group design using the SPSS (version 20) statistical software package. First, the analysis involved both descriptive and inferential statistics. The statistical tests of a non - parametric and parametric nature were employed at 0.05 conventional significance levels. The χ^2 analysis tested for any significant differences between the two study groups, while the t-test checked for statistically significant differences in the attitudes scores between the groups at each phase of the study.

Before the commencement of the study, a pre-test evaluation of attitudes was carried out in both the experimental group one and control group two based on a student attitudinal test and biological achievement scores as shown in Table 1 below.

Table 1: Pre-test Evaluation of Attitudes and Test scores

	Attitudes			Test scores		
Group	n	Mean	Std. Deviation	n	Mean	Std. Deviation
One (Experimental)	91	2.9236	.25037	91	18.5000	4.33643
Two (Control)	82	2.9591	.31799	82	19.5063	4.54852
t-test		t = -0.820	p = 0.413		t = -1.463	p = 0.145

As per the descriptive statistics on attitudes, the means (standard deviations) of the pre-test attitudinal scores were 2.9591(0.25037) for the control group and 2.9236(0.31799) for the experimental group. The statistical t-test results indicate that there was no significant level of difference in the pre-test attitudes of the two groups (t = -0.820, p > 0.05) before the experiment. Thus, this indicates that the initial attitudes towards biology for the two groups were equivalent.

Concerning the pre-test scores, the descriptive statistics show that the means (standard deviations) of the pre-test scores were 18.50(4.33) for the experimental group and 19.50(4.54) for the control group. The statistical t-test result indicated that there was no significant level of difference in the pre-test attitudes of the two groups (t = -1.463, p > 0.05) before the experiment. This indicated that the initial Biology score in Biology for the two groups was equivalent.

V. Results

The study first presents the gender differences in post-test scores and the group differences in the post-test scores.

Table 2: Gender differences in post-test scores

		Post-test scores				**Post-test scores**	
All Groups	n	Mean	Std. Dev	Experimental Groups	n	Mean	Std. Dev.
Male	163	18.7117	4.2770	Male (one)	79	17.2532	5.54577
Female	182	21.0824	4.3237	Female (three)	91	20.8571	6.54144
t-test	t = -5.110		p = 0.00		t = -3.842		p = 0.000

The descriptive statistics for the study groups indicate that means (standard deviations) for the post-test scores were 18.712(4.323) for the male students and 21.082(4.324) for the female students. The statistical t-test results indicate a significant difference in the post-test scores of the two groups (t = -5.114, p < 0.05) after the experiment. Further, in the descriptive statistics for the experimental groups, the means (standard deviations) of the post-test scores were 17.253 (5.546) for the male students and 20.857 (6.541) for the female students. The statistical t-tests indicate a significant difference in the post-test scores of the two experimental groups (t = -3.842, p < 0.05) after the experiment. In both cases, the t-test results were statistically significant, thus it indicates that the two groups had non -equivalent test scores after the experiment. The test score for girls was significantly higher compared to those exhibited by the boys. The finding seems to indicate that biology seems to be a favourite science subject for girls irrespective of the teaching strategy employed.

Table 3: Group differences in post-test scores

		Post-test scores				**Post-test scores**	
All Groups	n	Mean	Std. Dev	Experimental Groups	n	Mean	Std. Dev
Control	178	19.3315	3.6911	One (Male)	79	18.759	5.0134
Experimental	167	20.6347	5.0734	Three (Female)	91	22.318	4.5297
t-test	t = -2.740		p = 0.00		t = -4.819		p = 0.00

The descriptive statistics for the study groups indicate that means (standard deviations) for the post-test scores were 20.635(5.073) for the experimental group and 19.3315 (3.6911) for the control group. The statistical t-test results indicate a significant difference in the post-test scores of the two groups (t = -2.740, p < 0.05) after the experiment. Further, in the descriptive statistics for the experimental groups, the means (standard deviations) of the post-test scores were 22.3182(4.5297) for group three, and 18.7595 (5.0133) for group one. The statistical t-tests indicate a significant difference in the post-test scores of the two experimental groups (t = -4.819, p < 0.05) after the experiment.

In both cases, the t-test results were statistically significant, thus it indicates that the two groups had non -equivalent test scores after the experiment. The test score for the experimental was significantly higher compared to those exhibited by the control group. The finding indicates that computer-based collaborative concept mapping could have explained the differences in the post-test scores. Further, this conclusion is indicated by the performance exhibited by group three which was significantly higher than the performance of group one which was pre-tested.

Table 4: Group differences in post-test scores

		Post-test scores				**Pre-test scores**	
Control Group	n	Mean	Std. Dev	Groups	n	Mean	Std. Dev.
Two	84	18.6667	3.47568	Group One	88	18.500	4.33643

Four	94	19.9255	3.79371	Group Two	79	19.506	4.54852
t-test	t = -2.299		p = 0.023		t = -1.463		p = 0.145

The descriptive statistics for the study groups indicate that means (standard deviations) for the pre-test scores were 18.500 (4.3364) for control group one, and 19.506 (4.5485) for control group two. The statistical t-test results indicate there were no significant differences in the pre-test scores of the two groups ($t = -1.463$, $p > 0.05$) before the experiment. This indicates that the pre-test scores for the two groups confirmed there were no differences between group two and group one which was pre-tested.

Further, the descriptive statistics for the study groups indicate that means (standard deviations) for the post-test scores were 18.6667 (3.47568) for control group two, and 19.9255 (3.79371) for control group four. The statistical t-test results indicate a significant difference in the post-test scores of the two groups ($t = -2.299$, $p < 0.05$) after the experiment. Consequently, the study concluded that the two groups had non -equivalent test scores after the experiment. This suggests that the intellectual capabilities of the students in the two groups were equivalent before the treatment and this alleviated the non-equivalence between the groups during the experiment and help explain any statistical difference after the experiment.

VI. Discussion

The study observed that there were gender differences in the pre-test attitudes and scores but there were significant gender differences in the post-test groups. The difference could be explained by computer-based collaborative concept mapping as a learning strategy. Studies have shown individual differences in the application of learning strategies between male and female students (Ruffing *et al.,* 2015). Ardura and Galán (2019); Cheema and Mirza (2013) observed gender effects on academic achievement as girls showed higher levels of achievement in sciences. The gender gaps in science, technology, engineering, and math (STEM) tend to extend to higher education levels however, the disparities are not equal in all STEM majors (Cimpian *et al.,* 2020). For instance, there is a lower representation of women in computer science, engineering, and physics compared with biology, chemistry, and mathematics holds for all racial groups (Cheryan *et al.*, 2017). In the US, the male-to-female ratio among U.S. college majors in biology, chemistry, mathematics, and many other STEM fields is now about 1-to-1 while it is about 4-to-1 in physics, engineering, and computer science (PECS) (Cimpian *et al.,* 2020).

Second, the study observed that there were differences in the post-test scores and based on this finding, the study rejected the null hypothesis and concluded that CBCCM has a significant effect on students' academic achievement in biology. The effect of the CBCCM on students' attitudes toward biology is explained by theoretical and empirical literature. Considering that CBCCM is an active, blended learning activity, the effects can be explained by several studies which have shown that active learning impact learning by changing the way the learners construct and apply new knowledge (Jones *et al.*, 2012; Chen *et al.,* 2017) and the cumulative effect of knowledge awareness (Cheng & Chu, 2019; Kwon *et al.*, 2014).

CBCCM also supports collaborative learning which fosters students' creativity and problem-solving through intensive interaction, reflection and participation, thus the success of one student aids in the success of other students as well (Wu *et al.*,2013). Collaborative learning promotes knowledge acquisition and retention (Cheng & Chu, 2019) through reinforcement and cooperative learning activities (Ma *et al.*, 2020) and contributes towards the achievement of shared learning targets (Jones *et al.,* 2012; Sugano & Nabua, 2020). Collaborative problem-based learning (CPBL) helps improve students' learning attitudes, motivation and self-evaluation (Chao *et al.,* 2015).

The use of technological aids in learning improves educational outcomes (Sangrà & González-Sanmamed, 2010). For instance, the use of mindtools as 'intellectual partners' to facilitate critical thinking and high-order learning (Kazantzis & Hadjileontiadou, 2021) while serving as an extension of the mind as it can engage learners in constructing higher-order critical learning (Hwang *et al.*, 2011). These technological aids also situate learners in real-world and digital-world learning contexts (Hwang *et al.*, 2011) and promote self-evaluation and reflection during the learning process while providing immediate feedback (Serin, 2011).

In addition, interactive mediums such as text, graphs, audio, video, pictures, animation and simulation help pace learning (Tekbiyik & Akdeniz, 2010). The use of models, symbols (abstract) and various representations, in small teams (groupings) and integrative technology helps the students to explore the knowledge domains of the subject (Sugano &Nabua, 2020). Mindtools such as concept mapping tools are interactive and enjoyable (Abbas *et al.*, 2018). Technology aids promote social interaction, and group participation and facilitate social regulation during learning (Schneider & Preckel, 2017; Kwon *et al.,* 2014).

Mindtools provide the required scaffolding and thus are an effective way of assisting students to interpret and organize their knowledge structures (Hwang *et al.,* 2011). It also enriches the learning environment, which increases the effectiveness of lessons and makes learning and teaching more communicative (Gencer *et al.*, 2014). The use of collaborative and computer-aided instruction enhances self-learning, building experiences, communication skills, and cooperation among students (Elian & Hamaidi, 2018). Other advantages include the opportunities for individualised learning regarding learning pace and styles as well as learning the content before practice; allowing students to take more responsibility for their learning; and creating a more transparent learning environment carrying learning outside the walls of a classroom setting (Karadag & Keskin, 2017).

VII. Conclusion

The mastery of respiration concepts in a biology lesson in a secondary school represents learning progress and experience in a real-life context. The major findings of this study demonstrate the application of flipped learning approaches within the local context. Given the debate on the increasing adoption of flipped learning approaches in schools, the findings provide a platform where researchers and academicians can attest to the effectiveness of the flipped learning approaches as an effective approach to conventional learning approaches. Therefore, flipped learning approaches should be embraced as a potentially valuable learning approach tool, given the current shift towards learner-centred self–learning. However, the study was limited by its smaller sample size and homogeneity which would potentially affect the generalization of study findings; thus, the findings must be interpreted with caution.

References

[1]. Abbas, S. S., Eldin, A. S., & Elsayed, A. (2018). The effect of concept mapping and mind mapping utilization on students' understanding level: an empirical study. In Proc. of the Eighth International Conference on Concept Mapping Medellín, Colombia, 1(1), 1-10.

[2]. Aktamiş, H., Hiğde, E., & Özden, B. (2016). Effects of the Inquiry-Based Learning Method on Students' Achievement, Science Process Skills and Attitudes towards Science: A Meta-Analysis Science. Journal of Turkish Science Education (TUSED), 13(4), 248-261.

[3]. Allen, J., Gregory, A., Mikami, A., Lun, J., Hamre, B., &Pianta, R. (2013). Observations of effective teacher-student interactions in secondary school classrooms: Predicting student achievement with the classroom assessment scoring system—secondary. School psychology review, 42(1), 76-98.

[4]. Aquino, J. E., & Bautista, R. G. (2022). CHEMIKA and Students' Academic Achievement in Chemistry. American Journal of Educational Research, 10(8), 501-507.

[5]. Ardura, D., & Galán, A. (2019). The interplay of learning approaches and self-efficacy in secondary school students' academic achievement in science. International Journal of Science Education, 41(13), 1723-1743.

[6]. Ayaz, M. F., & Sekerci, H. (2015). The Effects of the Constructivist Learning Approach on Student's Academic Achievement: A Meta-Analysis Study. Turkish Online Journal of Educational Technology-TOJET, 14(4), 143-156.

[7]. Barmby, P., Kind, P. M., & Jones, K. (2008). Examining changing attitudes in secondary school science. International journal of science education, 30(8), 1075-1093.

[8]. Birgili, B., Seggie, F. N., & Oğuz, E. (2021). The trends and outcomes of flipped learning research between 2012 and 2018: A descriptive content analysis. Journal of Computers in Education, 8(3), 365-394.

[9]. Chao, C. Y., Chen, Y. T., & Chuang, K. Y. (2015). Exploring students' learning attitude and achievement in flipped learning supported computer-aided design curriculum: A study in high school engineering education. Computer Applications in Engineering Education, 23(4), 514-526.

[10]. Cheema, A. B., & Mirza, M. S. (2013). Effect of Concept Mapping On Students' Academic Achievement. Journal of Research & Reflections in Education (JRRE), 7(2).

[11]. Chen, S. L., Liang, T., Lee, M. L., & Liao, I. C. (2011). Effects of concept map teaching on students' critical thinking and approach to learning and studying. Journal of Nursing Education, 50(8), 466-469.

[12]. Cheng, L. C., & Chu, H. C. (2019). An innovative consensus map-embedded collaborative learning system for ER diagram learning: Sequential analysis of students' learning achievements. Interactive Learning Environments, 27(3), 410-425.

[13]. Christidou, V. (2011). Interest, Attitudes and Images Related to Science: Combining Students' Voices with the Voices of School Science, Teachers, and Popular Science. International Journal of Environmental and Science Education, 6(2), 141-159.

[14]. Cimpian, J. R., Kim, T. H., & McDermott, Z. T. (2020). Understanding persistent gender gaps in STEM. Science, 368(6497), 1317-1319.

[15]. Discipulo, L. G., & Bautista, R. G. (2022). Students' cognitive and metacognitive learning strategies towards hands-on science. Int J Eval & Res Educ ISSN, 2252(8822), 8822.

[16]. Elian, S. A., & Hamaidi, D. A. (2018). The effect of using flipped classroom strategy on the academic achievement of fourth-grade students in Jordan. iJET 2 (13), 110–125

[17]. García, T., Rodríguez, C., Betts, L., Areces, D., & González-Castro, P. (2016). How affective-motivational variables and approaches to learning predict mathematics achievement in upper elementary levels. Learning and Individual Differences, 49, 25-31.

[18]. Gencer, B. G., Gurbulak, N. & Adiguzel, T. (2014). A new approach in learning and teaching: the flipped classroom. In A.C. Ilhan, A. Isman, C. Birol & A. Eskicumali (Eds.), Proceedings of International Teacher Education Conference (pp. 881–888). Sakarya, Turkey

[19]. Gutiérrez-Braojos, C., & Salmerón-Pérez, H. (2015). Exploring collective cognitive responsibility and its effects on students' impact in a knowledge-building community / Exploring collective cognitive responsibility and its effects on the impact of students in a community for the creation of knowledge. Childhood and Learning, 38 (2), 327-367.

[20]. Han, S., Capraro, R., & Capraro, M. M. (2015). How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement. International Journal of Science and Mathematics Education, 13(5), 1089-1113.

[21]. Hwang, G. J., Shi, Y. R., & Chu, H. C. (2011). A concept map approach to developing collaborative Mindtools for context-aware ubiquitous learning. British Journal of Educational Technology, 42(5), 778-789.

[22]. Hwang, G. J., Hung, P. H., Chen, N. S., & Liu, G. Z. (2014). Mindtool-assisted in-field learning (MAIL): An advanced ubiquitous learning project in Taiwan. Journal of Educational Technology & Society, 17(2), 4-16.

[23]. Hwang, G. J., Hsiao, C. L. & Tseng, J. C. (2003). A computer-assisted approach to diagnosing student learning problems in science courses. J. Inf. Sci. Eng., 19(2), 229-248.

[24]. Hwang, G. J., Wu, P. H., & Ke, H. R. (2011). An interactive concept map approach to supporting mobile learning activities for natural science courses. Computers & Education, 57(4), 2272-2280.

[25]. Hwang, G. J., Wu, C. H., & Kuo, F. R. (2013). Effects of touch technology-based concept mapping on students' learning attitudes and perceptions. Journal of Educational Technology & Society, 16(3), 274-285.

[26]. Jones, M. E., Antonenko, P. D., & Greenwood, C. M. (2012). The impact of collaborative and individualized student response system strategies on learner motivation, metacognition, and knowledge transfer. Journal of computer-assisted learning, 28(5), 477-487.

[27]. Kaddoura, M., VanDyke, O., Cheng, B., & Shea-Foisy, K. (2016). Impact of concept mapping on the development of clinical judgment skills in nursing students. Teaching and Learning in Nursing, 11(3), 101-107.

[28]. Kaddoura, M., Van-Dyke, O., & Yang, Q. (2016). Impact of a concept map teaching approach on nursing students' critical thinking skills. Nursing & health sciences, 18(3), 350-354.

[29]. Karadag, R., & Keskin, S. S. (2017). The effects of flipped learning approach on the academic achievement and attitudes of the students. New Trends and Issues Proceedings on Humanities and Social Sciences, 4(6), 158-168.

[30]. Kazantzis, T., & Hadjileontiadou, S. (2021). Microgenetic Analysis of the Educational Robotics as Mindtools: A Case in the Construction of the Concept Speed. Research on E-Learning and ICT in Education: Technological, Pedagogical and Instructional Perspectives, 219-237.

[31]. Kevser, H. (2020). The effects of the flipped classroom on deep learning strategies and engagement at the undergraduate level. Participatory Educational Research, 8(1), 379-394.

[32]. Kim, J. E., Park, H., Jang, M., & Nam, H. (2017). Exploring flipped classroom effects on second language learners' cognitive processing. Foreign Language Annals, 50(2), 260-284.

[33]. Kudish, P., Shores, R., McClung, A., Smulyan, L., Vallen, E. A., & Siwicki, K. K. (2016). Active learning outside the classroom: Implementation and outcomes of peer-led team-learning workshops in introductory biology. CBE—Life Sciences Education, 15(3), ar31.

[34]. Kwon, K., Liu, Y. H., & Johnson, L. P. (2014). Group regulation and social-emotional interactions observed in computer-supported collaborative learning: Comparison between good vs. poor collaborators. Computers & Education, 78, 185-200.

[35]. La Velle, L. B., McFarlane, A., & Brawn, R. (2003). Knowledge transformation through ICT in science education: A case study in teacher-driven curriculum development-case study 1. British Journal of Educational Technology, 34(2), 183-200.

[36]. Låg, T., & Sæle, R. G. (2019). Does the flipped classroom improve student learning and satisfaction? A systematic review and meta-analysis. AERA open, 5(3), 2332858419870489.

[37]. Liang, X. L., He, J., & Liu, P. P. (2020). The influence of cognitive ability on academic performance of junior middle school students: a mediated moderation model. Psychological Development in Education, 36, 449-461.

[38]. Lin, H. C., & Hwang, G. J. (2019). Research trends of flipped classroom studies for medical courses: A review of journal publications from 2008 to 2017 based on the technology-enhanced learning model. Interactive Learning Environments, 27(8), 1011-1027.

[39]. Liu, P. L., Chen, C. J., & Chang, Y. J. (2010). Effects of a computer-assisted concept mapping learning strategy on EFL college students' English reading comprehension. Computers & Education, 54(2), 436-445.

[40]. Ma, N., Du, L., Zhang, Y. L., Cui, Z. J., & Ma, R. (2020). The effect of interaction between knowledge map and collaborative learning strategies on teachers' learning performance and self-efficacy of group learning. Interactive Learning Environments, 1-15.

[41]. Mahasneh, A. (2017). The effect of using electronic Mind Mapping on Achievement and Attitudes in an introduction to educational Psychology Course. The new educational review, 47(1), 295-304.

[42]. Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among US students. Science education, 95(5), 877-907.

[43]. Martínez, G., Pérez, Á. L., Suero, M. I., & Pardo, P. J. (2013). The effectiveness of concept maps in teaching physics concepts applied to engineering education: Experimental comparison of the amount of learning achieved with and without concept maps. Journal of Science Education and Technology, 22(2), 204-214.

[44]. McCarthy, J. (2016). Reflections on a flipped classroom in first-year higher education. Issues in Educational Research, 26(2), 332-350.

[45]. McLean, S., & Attardi, S. M. (2018). Sage or guide? Student perceptions of the role of the instructor in a flipped classroom. Active learning in higher education, 1469787418793725.

[46]. Nesbit, J. C., & Adesope, O. O. (2006). Learning with concept and knowledge maps: A meta-analysis. Review of educational research, 76(3), 413-448.

[47]. Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. Studies in Higher Education, 31, 199–218

[48]. Nja, C. O., Idiege, K. J., & Obi, J. J. (2017). Effect of the use of ICT on Chemistry Performance. Education for Today, 13(1), 148-153.

[49]. Nja, C. O., Orim, R. E., Neji, H. A., Ukwetang, J. O., Uwe, U. E., & Ideba, M. A. (2022). Students' attitude and academic achievement in a flipped classroom. Heliyon, 8(1), e08792.

[50]. Potvin, P., &Hasni, A. (2014b). Analysis of the decline in interest towards school science and technology from grades 5 through 11. Journal of Science Education and Technology, 23(6), 784-802.

[51]. Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: a systematic review and meta-analysis. Psychological Bulletin, 138(2), 353- 363

[52]. Ruffing, S., Wach, F. S., Spinath, F. M., Brünken, R., & Karbach, J. (2015). Learning strategies and general cognitive ability as predictors of gender-specific academic achievement. Frontiers in Psychology, 6, 1238.

[53]. Saglam, D., & Arslan, A. (2018). The Effect of Flipped Classroom on the Academic Achievement and Attitude of Higher Education Students. World Journal of Education, 8(4), 170-176.

[54]. Sangrà, A., & González-Sanmamed, M. (2010). The role of information and communication technologies in improving teaching and learning processes in primary and secondary schools. Australasian Journal of Educational Technology, 26(8).

[55]. Savelsbergh, E. R., Prins, G. T., Rietbergen, C., Fechner, S., Vaessen, B. E., Draijer, J. M., & Bakker, A. (2016). Effects of innovative science and mathematics teaching on student attitudes and achievement: A meta-analytic study. Educational Research Review, 19, 158-172.

[56]. Schneider, M. (2012). Knowledge integration. In N. M. Seel (Ed.), Encyclopedia of the sciences of learning (pp. 1684–1686). New York, NY: Springer.

[57]. Schneider, M., & Preckel, F. (2017). Variables associated with achievement in higher education: A systematic review of meta-analyses. Psychological Bulletin, 143(6), 565 – 600

[58]. Schroeder, N. L., Nesbit, J. C., Anguiano, C. J., & Adesope, O. O. (2018). Studying and constructing concept maps: A meta-analysis. Educational Psychology Review. 431-455.

[59]. Serin, O. (2011). The Effects of the Computer-Based Instruction on the Achievement and Problem-Solving Skills of the Science and Technology Students. Turkish Online Journal of Educational Technology-TOJET, 10(1), 183-201.
[60]. Simonneaux, L., Albe, V., Ducamp, C., & Simonneaux, J. (2005). Do High-School Students' Perceptions of Science Change When Addressed Directly by Researchers? Eurasia Journal of Mathematics, Science and Technology Education, 1(1), 21-40.
[61]. Sjøberg, S., & Schreiner, C. (2010). The ROSE project. An overview and key findings, 1-31.
[62]. Shi, Y., & Qu, S. (2022). The effect of cognitive ability on academic achievement: The mediating role of self-discipline and the moderating role of planning. Frontiers in Psychology, 13, 1014655.
[63]. Shute, V. J., & Rahimi, S. (2017). Review of computer-based assessment for learning in elementary and secondary education. Journal of Computer Assisted Learning, 33(1), 1-19
[64]. Soltani, A., & Nasr, A. R. (2010). Research Approaches in Science and Engineering Education. Iranian Journal of Engineering Education, 12(47), 63-80.
[65]. Strohmyer, D. A. (2016). Student perceptions of flipped learning in a high school math classroom (Doctoral dissertation, Walden University).
[66]. Sugano, S. G. C., & Nabua, E. B. (2020). Meta-Analysis on the Effects of Teaching Methods on Academic Performance in Chemistry. International Journal of Instruction, 13(2), 881-894.
[67]. Sümeyye, A. K. C. A. (2018). Digital Humanities: A New Approach. Turkish Librarianship, 32(3), 193-207.
[68]. Sung, H. Y., & Hwang, G. J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. Computers & Education, 63, 43-51.
[69]. Tsai, C. W., Shen, P. D., Chiang, Y. C., & Lin, C. H. (2017). How to solve students' problems in a flipped classroom: a quasi-experimental approach. Universal Access in the information society, 16(1), 225-233.
[70]. Tekbiyik, A., & Akdeniz, A. R. (2010, December). A meta-analytical investigation of the influence of computer-assisted instruction on achievement in science. In Asia-Pacific Forum on Science Learning & Teaching (Vol. 11, No. 2).
[71]. Ullah, O., Mughal, A. W., &Nudrat, S. (2021). Enhancing Student Academic Performance: Application of Concept Mapping. Multicultural Education, 7(3).
[72]. Usak, M., Erdogan, M., Prokop, P., & Ozel, M. (2009). High school and university students' knowledge and attitudes regarding biotechnology: A Turkish experience. Biochemistry and molecular biology education, 37(2), 123-130.
[73]. Veas, A., Castejón, J. L., Miñano, P., & Gilar-Corbí, R. (2019). Relationship between parent involvement and academic achievement through metacognitive strategies: A multiple multilevel mediation analysis. British journal of educational psychology, 89(2), 393-411.
[74]. Youssef, H. A., & Mansour, M. A. (2012). The effect of concept mapping on students' learning achievements and interests at Taif University. Life Science Journal, 9(2s), 346-353.
[75]. Wu, P. H., Hwang, G. J., Milrad, M., Ke, H. R., & Huang, Y. M. (2012). An innovative concept map approach for improving students' learning performance with an instant feedback mechanism. British Journal of Educational Technology, 43(2), 217-232.

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