ORIGINAL ARTICLE

The Flipped Classroom: Enhancing Self-confidence among Adolescents Studying Chemistry

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ABSTRACT

One of the key aims of post-primary education in Ireland is to develop all aspects of the individual, such as the creative, critical, and intellectual to prepare them for working life, for living in the community, and for leisure. Student self-confidence and student agency are critical to the students' development at this stage. The flipped classroom is a model within the blended learning pedagogy and is one that has gained considerable attention in educational circles since school closures due to the COVID-19 pandemic. The benefits of the flipped classroom toward developing student self-confidence are noteworthy. However, at the national and international level, the vast majority of research on the flipped classroom is third-level focused. This paper discusses a number of issues that arose from data collected from research carried out by the author and how the flipped classroom could benefit adolescents preparing for the Irish Leaving Certificate Chemistry summative examination. The results obtained in this study are significant as little research has been carried out on the implementation of the flipped classroom within an Irish secondary school setting. Video lessons are often seen as the core resource in the implementation of the flipped classroom. However, video lessons alone were insufficient for developing student self-confidence. Students required multiple resources, particularly resources focused on assessment, to bolster their self-esteem. It was found that the successful implementation of the flipped classroom was achievable, but scaffolding was required for these adolescents. Some scaffolding was also required initially for teachers as almost all teachers involved in this study were not familiar with the flipped classroom concept. Teachers required a guide in terms of the implementation of new teaching methods. The technology is currently available to create high quality resources for the flipped classroom; however, in respect to policy development, the support for online learning should be pedagogy led as opposed to technology led.

KEY WORDS: The flipped classroom; self-confidence; student agency; student-centered learning; assessment

INTRODUCTION

The provision for online teaching and learning in the education system in Ireland has been steadily increasing over the past 10 years. The use of online learning platforms across all areas in education accelerated in March 2020 when the Irish government announced that all schools and colleges had to close for the remainder of the school year due to the COVID-19 pandemic. A model of blended learning – the flipped classroom – has become considerably more popular in the Irish educational system. The flipped classroom is a form of blended learning where a student is first exposed to new material outside of class, usually in the form of an online presentation. The flipped classroom is a model within blended learning (Stein and Graham, 2020). In simple terms, the student studies new material outside the classroom not previously taught by the teacher. The teacher then further advances the knowledge that the student has acquired by means of active learning pedagogy inside the classroom. The flipped classroom aims to facilitate teachers to make better use of the face-to-face sessions through minimizing teacher lecture time and increasing students' active learning, collaboration, and scaffolding (Bergmann and Sams, 2012). Typically, the flipped classroom utilizes video lessons, but other resources may be used. The flipped classroom has a number of well-documented strengths such as more efficient use of class time (Cole and Kritzer, 2009), greater opportunities for active learning for students (Gannod et al., 2008), as well as an increase in student responsibility for learning (Overmyer, 2012).

The concept of the flipped classroom began in the 1990s when technology started to improve, similar to that of the overall concept of blended learning. Blended learning at the time was being further explored as technology allowed for modified teaching pedagogies. It was not until 2012 however that the flipped classroom became well known. John Bergmann and Aaron Sams, two American high school chemistry teachers, are credited with being the pioneers of the flipped classroom. The two teachers during the 2007/08 school year recorded all of their chemistry lectures and students were asked to watch the video lessons for homework and take notes on what they learned. The concepts would then be assessed and expanded on as well as laboratory experiments carried out (Bergmann and Sams, 2012). The two authors reminded their readers that while there are different ways of implementing the flipped classroom, the use of video lessons was the core instructional tool.

Video lessons can be a powerful educational tool in a teacher's arsenal and have several highly commendable advantages such as allowing students to have a greater opportunity to understand difficult concepts by being able to rewatch the lesson and to study in their own time and learn at their own pace (Peterson, 2017). The ability for students to learn at their own pace is an important factor in the concept of student-centered learning. As highlighted by Gibbs (1995), one of the benefits of student-centered learning is the ability for students to make key decisions about their learning. In addition, the inclusion of the flipped classroom can help improve a student's confidence in the subject. Student-centered learning strategies can lead to a greater sense of empowerment by means of personal agency. Self-esteem or the level of confidence in a subject is hugely important in encouraging a student to consider studying the subject further at university level. The beliefs that adolescents have about their abilities influence their choices as well as their lives (Bandura, 2006). Interest and achievement in a subject are related to a student's academic success in that subject and are likely to lead to even further interest in it (Brown and Lent, 2006; Kidman, 2009 cited in Palmer et al., 2017).

From a pedagogy viewpoint, by implementing the flipped classroom, the traditional brick and mortar classroom could be radically overhauled. Teachers could, in theory, dedicate more time to active learning strategies such as discussion, group work, and demonstration. In respect to the Leaving Certificate Chemistry, the state examination taken by students at the end of secondary education in Ireland, a lack of time is seen as a barrier to engaging with more active learning pedagogies. Mazur (2009) articulates that "education is so much more than just information transfer, especially in science. New information needs to be connected to preexisting knowledge in the student's mind. Students need to develop models to see how science works." (pp. 50–51). The flipped classroom if implemented correctly can achieve this by reducing the didactic mode of information transfer within the classroom. Students learning new material outside of the classroom have a greater opportunity to make their own connections which could further enhance their learning.

My PhD research found that, if certain guidelines were followed, the flipped classroom could lead to greater self-efficacy and self-confidence among students (Gallagher, 2022). My research was conducted over the period of 2019–2022 on students sitting the Leaving Certificate Chemistry course. As previously mentioned, the flipped classroom has many strengths to warrant its use by educators. However, there are a significant number of variables that need to be considered to determine the merits of the flipped classroom. How much of the course can or should be flipped? Do some subjects lend themselves to the flipped classroom more than others? Do variables such as age and gender play a role in determining the success of the flipped classroom? As noted, the majority of research published on the flipped classroom centers on undergraduate students. While there is research on secondary school student's use of flipped classrooms, there was no research on Irish secondary school students in chemistry using flipped classrooms until my PhD study.

Research Problem

In the Irish secondary school context, the majority of students choose the established Leaving Certificate program (Citizens Information, 2022). This 2-year program covers a wide range of subjects. Students completing their Leaving Certificate are usually between 17 and 19 years of age. The research for this article was carried out by the author and was based on the Leaving Certificate Chemistry course where students must undergo a high-stakes summative examination at the end of the course.

The research for this study centered around the main research question: How can online technology support the teaching of Leaving Certificate Chemistry? This question contained a number of sub-research questions such as:

1. What are the factors that enhance and hinder the online program of work for chemistry students and their teachers?
2. What is the most appropriate balance in practice of online and face-to-face teaching and learning?
3. Will the use of these online lessons developed in this research allow teachers more freedom to conduct more laboratory practical work or other forms of active learning in school?
4. How do students value the experience of using online resources to enhance their learning in Leaving Certificate Chemistry?

To answer the research questions a number of aims were devised:
- To design, implement, and evaluate the use of online Leaving Certificate Chemistry lessons.
- To convert the entire Leaving Certificate Chemistry syllabus into a series of online lessons and resources.
- To evaluate best effective pedagogy of the use of the online chemistry lessons in helping to teach Leaving Certificate Chemistry.

To investigate the advantages and disadvantages of the online teaching of chemistry.

METHODOLOGY

The study involved converting the entire Leaving Certificate Chemistry syllabus (Department of Education and Science, 1999) into a series of approximately 60 video lessons and accompanying resources (assessment tasks, quizzes, model solutions, and revision notes), which were then uploaded onto a website (see www.theconicalflask.ie). Chemistry students and teachers were encouraged to use the resources on the website throughout the 2-year period need to complete the Leaving Certificate Chemistry program. This study utilized a multi-method approach to maximize the robustness of the findings by triangulating data from different sources (questionnaires, semi-structured interviews, Google Analytics,

and a case study).

Participants

A total of 410 questionnaires were collected as well as interview data from 16 students and eight teachers. The study took place over two cycles. Cycle 1 involved the trialing of the resources on the website and the data collected were used to improve the educational resource. Cycle 2 took place in the second year and involved implementing the additional resources based on the feedback from cycle 1 as well as evaluating the effectiveness of the updated resources. Participation was entirely voluntary. All participants had to sign a consent form before providing responses. In the case of participants under the age of 18, written consent from their parents/guardians was obtained. All responses and interview data collected were stored and then deleted in conjunction with UCC's code of research conduct policy. Before data collection could be conducted, the researcher was required to obtain ethical approval by the university by means of a Social Research Ethics Committee (SREC) application. The SREC Application sought all details from the researcher in how data was to be collected and analyzed. In addition, the SREC Application highlighted the UCC guidelines to follow. The relevant guidelines will be discussed in the following section. The researcher obtained ethical approval to collect data from students following a successful SREC Application.

RESULTS AND DISCUSSIONS

Cycle 1

The research produced a number of findings, some were, and some were not expected. From a technical standpoint, results collected were predictable. High quality video and audio were required as well as easy website navigation. Students and teachers regularly stated in their feedback that while the video quality was good, the audio was too low, and they found it difficult to follow the video lessons. The majority of students used a mobile device to access the website so playability on mobile devices was critical. However, from a teaching and learning viewpoint, the results collected throughout cycle 1 found the application of the flipped classroom to be ineffective. Teachers felt the online teaching and learning package was good but needed improving. Student feedback regularly stated they were unsure if learning was taking place. They also cited a lack of confidence when using the video lessons in comparison with using paid tuition. High quality videos were necessary to ensure students watched the lessons, but the videos by themselves were insufficient. This was a recurring finding obtained through questionnaires and interviews at the end of the first cycle from both students and teachers. Students, when interviewed about the matter, consistently stated that they were unsure if they were learning or not. Video lessons are a very powerful educational tool (Peterson, 2017). They allow students to pause, play, and rewind the lessons thus developing their self-efficacy in the subject further. Teachers also reported that they were unsure if learning had occurred and to what

extent, with most teachers referring to learning as shallow. In addition, teachers were unsure of the flipped classroom as no teacher had previously implemented this educational concept into their own teaching. The flexibility of when and how much to use the flipped classroom is an important factor and can be challenging for teachers. Teachers require time to incorporate new pedagogies into their teaching and to develop confidence utilizing them – this is not a new phenomenon (Pajares, 1992).

The semi-structured interviews also discovered that students were not confident with the flipped classroom primarily due to a lack of assessment resources. Assessment and student performance is also very much linked to self-confidence. Assessment can provide positive reinforcement and reassurance for students that they are capable of achieving the grade they desire in chemistry (Bandura, 2006 cited in Palmer et al., 2017). This thought process is not overly surprising as the Leaving Certificate Chemistry course is a high stakes competitive examination. Furthermore, students performing well provides reassurances to the teacher that they are on target to achieve the learning outcomes. Therefore, that just like a traditional brick and mortar classroom, assessment resources are a necessity for any success of the flipped classroom in respect to the Leaving Certificate in Ireland.

Cycle 2

Assessment resources in addition to other resources were implemented before the commencement of Cycle 2. Again, this is not a new concept as students selecting what resources to use and how to use them is very much in the realm of student-centered learning (Gibbs, 1995). However, this concept within the flipped classroom conversation is somewhat limited and warrants further discussion. The results obtained from Cycle 2 presented the flipped classroom in a far more favorable light by both students and teachers.

Almost all responses collected from students rated the assessment resources favorably. Assessment and student performance is very much linked to self-confidence (McMillan and Hearn, 2008). Assessment can provide positive reinforcement for students that they are capable of achieving the grade they desire (Bandura, 2006 cited in Palmer et al., 2017). Self-confidence is perhaps even more important in a flipped classroom environment as students are encouraged to learn new material without the presence of their teacher. Students throughout Cycle 2 consistently reported feeling more confident studying chemistry using the video lessons alongside assessment resources. Ultimately, COVID-19 prevented a final assessment to determine their final result, however many students reported that they believed that they could perform better in examinations with interviewed students stating that their average class test results had improved. This indicates an increase in self-efficacy in Cycle 2 when compared to Cycle 1. Representative student comments were:

> I used the model questions when I watched a video. I did the same for the experiments. It was really helpful to me. I feel I was more confident I knew the stuff I was studying

due to it. (Student 1)

> The model questions were fantastic and so easy to fill in and they're all actually examination paper questions. Whenever I have a test, I use those model questions to test myself. (Student 2)

Teachers reported in their semi-structured interviews that their students were more confident attempting higher level examination questions and performed better in class examinations by providing more detailed answers. They also reported that this increased confidence led to course content being completed faster than usual. See below for two teachers' comments:

> We were ahead of schedule and the students were more confident in class and more willing to answer questions. Everyone seems to be on the same page which never happens. Long may it last! Most students are averaging above 70% which isn't the norm, but I have a good class. I would've loved to see how they got on in the summer. (Teacher 4)
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> We're ahead particularly for the 5th years [students aged 17]. The 5th years are using examination papers a lot more than we ever did. It also probably would've been the first time in years that we would have done all the mandatory experiments. (Teacher 5)

Data analysis of cycle two brought about two findings. First, the use of video lessons by themselves may not be enough for efficient learning and long-term memory retention. This is somewhat complex as it is also dependent on how the teacher utilizes blended learning in the classroom. Second, students consistently reported that learning was more effective when they were being active. Students often referred to highlighting and making annotations on their study notes while watching video lessons, for example:

> The YouTube videos are great. You can pause and take notes or answer questions. You can rewind if you missed something. It is so much better than past year. (Student 4)

The use of the assessment resources was also carried out throughout or after the completion of a video lesson. This provided growing evidence toward students' preference for multimodal learning which in turn generated confidence in students. The use of examination style self-assessments provided reassurances to students while further enhancing their self-confidence. One can conclude from the analysis of data that multimodal learning exists online as well as offline.

Best teaching pedagogy today is often centered around the concept of multimodal learning. Multimodal learning, sometimes referred to as multimedia learning, is the use of multiple learning styles at the same time (Moreno and Mayer, 2007). Studies have shown that students learn best when educators appeal to multiple learning styles at the same time as multimodal strategies encourage the learner to stay focused, engaged, and absorb information on a deeper level (Moreno and Mayer, 2007). The delivery and practice of multimodal learning strategy is where the key differences arise. Meyer notes this in his research and opts for a view of multimodal design as student-centered rather that technology-centered. Lajoie (2000) makes the following comment:

> Changes in the availability and flexibility of technologies are allowing for greater creativity in the ways in which these technologies are used for education and training" and asks this question: "Are these changes in educational use driven by learning and instructional theories, or do the technological advances drive them? (Cited in Farías et al., 2007, p. xvii)

This is an important question to consider especially in recent years. Since the COVID-19 pandemic closing schools, there has been a dramatic increase in discussion about the use of online resources. There are a great many online resources present in the form of videos, games, articles, images, recording, etc. There is a greater awareness by teachers of new online resources available. As an educator, we ought to consider the implementation of such resources. The educational merit of online resources needs to be questioned. The quality and relevance of educational resources need to be probed. Teachers involved in my study stated that a lot of online resources were not specific to the Irish chemistry curriculum. Teachers stated that some of the online resources available were ostentatious and distracted from the end result – to help students learn. There is of course a difference between passing on information and students actually learning, and this applies to the flipped classroom especially. It was evident from the study that students required online resources to stimulate multimodal learning as best practice.

CONCLUSION

This study found that the flipped classroom has a lot of potential to enhance student self-confidence but only if certain guidelines were followed. The use of video lessons by themselves was ineffective for those students concerned about achieving high results in chemistry. A suite of comprehensive resources was required that catered for multimodal learning as well as all aspects of the Leaving Certificate Chemistry course. Other resources, particularly those that were assessment-orientated were required to bolster student agency and thus increase student self-confidence. This is not surprising as Leaving Certificate Chemistry is a high-stakes examination and competition for points to attend college is currently at an all-time high. Assessment and student performance is very much linked to self-confidence (McMillan and Hearn, 2008).

Students regularly stated that they enjoyed highlighting their study notes while watching video lessons which is a form of active learning and is very much student-centered learning. They took charge of their own learning but could only do so if scaffolding was provided. Students reported that they enjoyed being able to pause and rewind a video lesson to take notes etc. which is in keeping with the literature (Peterson, 2017).

Teachers involved in this study stated at the aftermath of Cycle 2 that they had time to undertake field trips, they exposed their students to more examination style questions, or managed to complete all the mandatory experiments. Experimentation is a crucial part to a chemistry student's schooling as it promotes confidence and enjoyment (Toplis, 2015). Teachers were impressed with their students' ability to learn chemistry from home and spoke enthusiastically on how their classrooms were now more question and discussion based. There was an element of uncertainty about this question as school closures resulted in less time in the classroom and teachers were unsure exactly how much additional time was afforded to them. However, teachers were unanimous in their belief that the use of blended learning did allow them additional time to use other pedagogies within the classroom. To conclude, teachers saw value in the flipped classroom but also appreciated teacher autonomy which is in keeping with the literature (Bull et al., 2012).

RECOMMENDATIONS FOR FUTURE STUDIES

Based on the findings of this study, a number of aspects of the research have been identified which could add more knowledge to the present research.

First, this study was only carried out on Leaving Certificate Chemistry students. It would be interesting to determine if the success of online learning could be replicated for other Leaving Certificate science subjects. Similarly for those subjects completely different to science, for example, in a language subject such as Irish, German, or French or a practical subject such as engineering or art where their course structures are very different. In other words, what is the transferability of blended learning for other subjects? No doubt the structure of online resources would have to be modified in some fashion. It would be very interesting to determine if online learning is more suitable for specific subjects. Could blended learning pedagogy and its models be utilized in other subjects as well chemistry?

Second, as this study was conducted on 17–19-year-old students of chemistry, it would be beneficial to conduct a similar study on students studying science at the Junior Cycle level. These students are typically aged between 12 and 15. Is online learning appropriate for younger students studying science? In general, these students require more guidance from teachers so it would be an interesting study to determine if teachers alter their online learning teaching strategies. Would teachers implement less of a blend in blended learning? Could the flipped classroom model be efficiently utilized for younger students? There are many questions that arise from this viewpoint and that would certainly be of interest to educators and policy implementers.

Finally, could the use of online learning be implemented to a greater extent for students with learning difficulties? Some teachers stated in their responses that the resource was particularly noteworthy for students who have audio and visual impairments. In addition, the online resource could be of significant interest to students who have dyslexia or other forms of learning difficulties. This would be a very worthy area of research to conduct to help improve the schooling of these students. Students regularly referred to the ability to pause and rewind a video if they missed or did not understand what was being taught. This is a very powerful learning tool as in the live classroom students may not get this type of opportunity. Could the use of online technology improve the likelihood of these students attending third level education? Or make chemistry more appealing to these students? There are many questions that come to light from this viewpoint, and it would certainly be a commendable study.

CLOSING REMARKS

The design of video lessons and resources requires both technical and pedagogical expertise. It also requires a significant amount of time to carry out. High quality hardware and software tools for video creation are necessary. It is both expensive and time consuming to create a video lesson which is a barrier to blended learning at secondary school level. The website must be easy to navigate, and the teacher clears in their teaching.

Implementation is not straight forward in relation to online learning. As stated previously, there are many barriers to the implementation. In addition, the flipped classroom pedagogy is relatively new in Ireland and teachers must be shown best practice and teacher autotomy respected. Before COVID-19 there has been limited information given to teachers on the pedagogy of online teaching and learning, essentially it has been technology led. However, school closures as a result of the COVID-19 pandemic have likely sped up the process of up-skilling teacher expertise in this area.

The website *The Conical Flask* supported the teaching and learning of Leaving Certificate Chemistry. Video lessons can be an important educational tool for learners, but it becomes more powerful when video lessons are coupled with additional resources that help to improve self-confidence and cater toward multimodal learning. The flipped classroom allows for more active learning within the classroom such as laboratory work which in turn can increase self-confidence among students and so it is a viable pedagogy for the teaching of chemistry to secondary school students.

Ethical Statement

UCC academic staff and postgraduate research students who are seeking ethical approval should complete this approval form. Ethical review by the Social Research Ethics Committee (SREC) is required where the methodology is not clinical or therapeutic in nature and proposes to involve:

- direct interaction with human participants for the purpose of data collection using research methods such as questionnaires, interviews, observations, and focus groups;

- Indirect observations with human participants, for example, using observations, web surveys, etc.;
- Access to, or utilization of, anonymized datasets;
- Access to, or utilization of, data or case files/records concerning identifiable individuals; and
- Conducting Internet research or research online.

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