Online adaptation strategies for active learning methodologies in STEM education

Ana Carolina S. Leandro[1], Eduarda C. Maia[2], Ingrid C. Alves[3], Larissa P. C. Santos[2], Thayná Cristina F. de Andrade[2], Carla Francisca S. de Moura[4], Dianne M. Viana[2], Maura Angelica M. Shzu[1], Simone Aparecida Lisniowski[5], Aline Souza de Paula[2]

[1] Faculty of Gama, University of Brasília, Brasília, Brazil
[2] Faculty of Technology, University of Brasília, Brasília, Brazil
[3] Chemistry Institute, University of Brasília, Brasília, Brazil
[4] Faculty of Communication, University of Brasília, Brasília, Brazil
[5] Faculty of Education, University of Brasília, Brasília, Brazil

Email: anacarolinaleandro15@gmail.com, eduardacomercial@gmail.com, ingriddecastroalves@gmail.com, larissapsanntos@gmail.com, thaynacristina.ok@gmail.com, carlafsmoura@gmail.com, diannemv@unb.br, maura@unb.br, psicosimone@gmail.com, alinedepaula@unb.br

Abstract

Due to Covid-19 pandemic, adaptations for carrying out remote work have become necessary in various sectors of society. Among these, the educational area was one of the most impacted and, with the goal of creating a "new normal", activities that used to be face-to-face are now performed online. Considering the importance of society-university integration, the university outreach programs, which form one of the pillars of the public university, also had to be adapted so the activities would continue. This paper presents the planning and execution strategies adopted by the Fast Girls outreach project team. This project is an initiative of the Faculty of Technology in partnership with other units of the University of Brasília and has the purpose of motivating girls and young women, students of basic public education from the outskirts of Brasília to pursue careers in the STEM areas (Science, Technology, Engineering and Mathematics). In this process, active teaching-learning strategies based on pedagogical workshops with hands-on activities, games, interactive lectures, women's testimonials, and conversation rounds were used. Meanwhile the difficulties encountered, as well as the results achieved were identified and discussed, highlighting the enriching character of these procedures for the undergraduate students in terms of their ability to adapt to the execution of the teaching-learning methods in face of the new reality. In this conception, the work presents positive results, extending the benefits of the use of active learning strategies beyond basic education, reaching undergraduate students, even in times of distance education.

Keywords: Active Learning; STEM Education; Online Workshops; Distance Education.

1 Introduction

University extension is one of the three pillars of public university, whose main role is to establish continuous communication between the internal and external community. Through it, the academic community has the opportunity, by sharing knowledge, to contribute to the solution of social problems, to reduce inequalities and promote development. Along these lines, the research and extension project "Fast Girls" from the University of Brasilia has existed for 8 years and its main objective is to promote gender equity in the exact courses, most specifically, in the engineering courses. The project was born due to the low number of women in the areas of exact sciences and technologies, which, according to Andréa Barreto (2014), reaches only about 32%. The actions aim to encourage public education students to pursue a career in the areas of Science, Technology, Engineering and Mathematics (STEM) through active learning methodologies, as well as strategies that encourage reflection on the role of women in society and the factors that influence their choices.

The project in its usual format has been conquering the public of basic education and collecting, together with the schools involved, achievements reflected both in the contentment of the members and in the number of approvals in higher education. With the pandemic, the project had to be adapted to a format that had not been foreseen, and it naturally had to face new challenges. With the new environment and new discoveries, the process of reinventing oneself, which is naturally part of the human condition, took on this context, within a fast and somewhat frightening pace, but rich in learning. It is not easy to adapt strategies which refers to

active involvement to the virtual model, knowing that this result is often enabled after integration dynamics, welcoming looks and gestures that facilitate the feeling of belonging to the new group.

Active learning methods and strategies are the foundation of the Fast Girls project and they mean "anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes." (Felder & Brent, 2009, p. 2). Activities such as games, debates, projects, and experiments tend to instigate students and help them during their learning process. Dismissing this way of working would be to radically alter the proposal that had already demonstrated its success. Thus, we decided to adapt STEM actions to the new virtual environment, and this required the team to exercise creativity and critical thinking, important educational skills in the 21st century, according to the OECD[1] (Ananiadou, K. and M. Claro, 2009).

Such active learning methodologies, as stated, aim at using different strategies and activities to go beyond traditional classes. Therefore, games, debates, experiments, and project development are used to instigate and help students to become protagonists of their own learning (Ziegelmeier & Topaz, 2015). In traditional classes, the teacher usually transmits information through content classes, which generally follow a somewhat predetermined method: lecture, exercises and assessment. However, such a method tends to generate more distractions, since the student does not have the chance to exercise other skills than only attend the class, and this model can be discouraging because it does not bring real motivation to the students (Prince & Felder, 2006). Therefore, to mitigate such difficulties, the main learning methodologies used in the Fast Girls project consist of the flipped classroom and hands-on experiences.

The flipped classroom, in general terms, consists of presenting the student with videos, texts, games and anything regarding the content that will be addressed in the classroom before it even takes place. In this type of dynamic, the student is led to gain autonomy in his studies, seeking to understand issues related to the subject before the class and, thus, maintaining the class time to clarify doubts, advance in the concepts learned and debate with colleagues (Tucker, 2012).

In addition to inverted classes, another method used refers to the practical activities that take place right after the lecture. Such methodology, called hands-on, consists of transforming all the learning acquired into manual activities, such as experiments. Hands-on activities involve several skills such as those needed to take measurements, build experiments, and analyse results (Corlu & Aydin, 2016). As a result, "learning becomes playful, realistic and pleasurable, with the potential to positively influence the interests of students pursuing a career in the fields of STEM" (Costa et al., 2020, p. 2). Experimental activities are especially important because they serve as practical examples of the theory studied and, as Srinath (2014) emphasizes, good practical examples have the ability to connect such theory with the practical applications of the subject covered. For classes in the areas of STEM, such an approach proves to be even more important, since the knowledge obtained needs to be specially consolidated and practiced with exercises (Costa et al., 2020).

In the first year of remote classes, three workshops were applied, all previously tested and evaluated in the virtual environment. Aspects such as the type of equipment used for online meetings, the eventual instability of the network and the time of remote exposure became part of the planning, as well as the use of strategies to hold the attention of girls in basic education. The workshops planning also added the logistics of providing the materials to meet the purposes of the workshops. The group's difficulty in translating the perception of its target audience should also be weighed, as one observes the participants shyness when they must express themselves in online meetings.

The present writing aims to document the adjustments made in the work form of the project Fast Girls to meet the security protocols required by COVID-19. The actions were designed to maintain the purpose of the active learning methods and strategies in the virtual environment and continue to contribute to the promotion of gender equity through activities that arouse the interest and empowerment of girls from the periphery to follow their training in areas that are not naturally designed for them. The article is divided into six topics: an introduction, the role of team in planning the activities and training the monitors, a topic detailing the

[1] Organization for Economic Cooperation and Development.

workshops applied and the strategies used, as well as an analysis of the results obtained, the conclusions and references used.

2 The role of team in planning the activities and training the monitors

Professors and undergraduate students from the Faculty of Technology and Faculty of Gama, in partnership with professors and undergraduate students in the areas of sociology, education and psychology at the University of Brasilia, formed a women team to address the issue of gender in an interdisciplinary and intersectional manner.

Among the main activities developed are the workshops, in which a topic within the scope of the subjects in the exact areas taught at the high school was approached, such as vectors, uniform rectilinear movement and Newton's Laws, electricity. Other activities, as lectures, always took place with a successful female personality, such as researchers, engineers and even sport personalities like Maiara Basso, a young Brazilian motocross champion. In these spaces, students had the opportunity to meet and talk to women of outstanding professional importance. In many events and meetings promoted, there are conversation circles to discuss gender, race, and social class issues, so that the students have space to express their opinions and thoughts. Generally, a film or documentary is presented and, based on what is seen, a space is then opened for discussion and exchange of ideas.

To enable the execution of these activities, at the beginning of each semester, a planning meeting is held with all members of the project team and a calendar of activities is drawn up for the respective school cycle, with proposals for activities and the people responsible for carrying them out.

As new workshops are conceived, other meetings are held with the team to verify and discuss the feasibility of each proposed theme. After the theme is approved, one of the professors is responsible for supervising the development of the workshop, having the role of guiding the monitors during the elaboration process. The professor accompanies all the planning stages of the workshop, suggesting ways to approach the content using active learning methods and strategies, and helping in the adjustments of the activity.

The ones responsible for running the workshops are undergraduate students from various STEM fields. When they join the project, these students undergo a training process, whose main purpose is to make them capable of acting as monitors. The above-mentioned process is divided into three stages. In the first moment, after joining the project, the students assume the role of observers, participating in meetings and workshops, and being able to clarify their doubts about the extension action.

In a second moment, the new members start helping in workshops organized by the more experienced monitors, giving assistance during the elaboration of the contents and contributing with new ideas. And, finally, in the third moment, the new monitor is responsible for creating a new workshop and putting it into practice, working together with the other project participants, as well as with the mentors, professors from the University of Brasilia.

3 Face-to-face and remote workshops: What is different?

The performance of the Fast Girls project, from the beginning of its activity in 2013, until the beginning of 2020, took place exclusively face to face. In this perspective, the process of planning and conducting workshops did not consider factors such as electronic resources availability by students, given that there was no need to supply the lack of contact between the participants through digital resources. Thus, until then, the team's main concern was to apply the active learning strategies to maximize the educational and personal experience built during the proposed activities.

Due to the COVID-19 pandemic, however, and the consequent social distance caused by the health crisis, the project had to face an unusual scenario. So, despite the difficulties identified, intending to fulfil its objectives, within which to encourage the engagement of students from the public school system in the Federal District

with the STEM areas, as well as allowing the exchange of experiences between the participants, the project began to carry on its role remotely only for the first time.

In relation to the different realities of internet access and the technological apparatus resources, workshops that could be carried out in the students' homes were carefully thought and planned, and the strategies already mentioned were used to motivate them. We set up workshops that used interactive tools, such as online games, and experiments that were easy to be reproduced, without posing any danger to students. Sending material kits enabled the continuity of activities. Also, it is possible to notice that without the material kits the activities would be focused on the theoretical scope, moving away from the idealization of the project, since in STEM classes, theory and practice should always be complementary (Srinath, 2014). It was also necessary for both parties to adapt to the use of virtual platforms to teach the classes.

That said, difficulties were naturally encountered, which did not prevent, however, the conduction of works in 2020, among which, we may point out the first three workshops planned and run by the team in the STEM area. The first was related the theme of vectors and their operations, while the last two referred to electricity, including the hands-on method, already used and highly valued in face-to-face workshops. We would also like to emphasize the essential role of the debates and lectures within the project. A transposition of this segment of activity was also planned in the remote modality, with all proposals proving to be successful.

In view of the success achieved, the following texts discuss how the works of the Fast Girls project were conceived and practiced before social distancing, as well as the practices adopted during the pandemic. Finally, the main difficulties encountered by the monitors during this transition are pointed out.

3.1 Face-to-face workshops

As explained so far, since 2013, the beginning of the Fast Girls project, it had been conducted face-to-face, through the promotion of workshops, lectures, or monthly meetings with the students. These contacts were always on Fridays, the day of the week reserved for their activities, and hosted at the University of Brasília or at the "Centro de Ensino Médio 404" in Santa Maria, the school the students attended, depending on the resources needed to carry out the activities.

The face-to-face workshops had 3 moments. Initially, an interactive class was held, when the project monitors not only presented the content, but also the students participated collaboratively during the explanations. The practical part of the workshop was developed with an aim at fixing the content covered in the presentation and showing how the concepts displayed were observed on a daily basis, thus enabling students to apply what they had previously learned. The third moment was for discussions and reflections about learning.

An example of this type of practice is the vector workshop. In it, a map of the University was given to students, who needed to use the vector properties presented by the monitors to find clues hidden on campus and, with each new clue, a puzzle had to be solved. The Time and Movement workshop, on the other hand, allowed students to apply the concepts of average speed and uniform rectilinear motion in remote control carts. In this dynamic, the students needed to go through automobile circuits with their carts, note the distance traveled, as well as the time spent to finish the route. Thus, through these interactive activities, students were able to observe in practice how physics, mathematics, and chemistry act in their daily lives.

3.2 Remote workshops

Vector workshop: the first workshop held online

The first workshop held during remote education had as an object of interest vectors and their mathematical operations, a similar proposal to the workshop held face-to-face, also on the same topic. The activity was planned to be applied in two meetings, both on Fridays. At first, the monitors responsible for the activities met so that the main ideas regarding the transposition of the activity to remote education were discussed. It was considered a good idea to develop a game on the theme, considering that, when well designed, it increases participation and interaction among students, favoring those who have difficulty assimilating the content through traditional methods. Therefore, with the objective of continuing to hold the workshops in such a way that the students were able to successfully learn the presented content, a small booklet was developed before

each meeting. It had a light and relaxed look, containing information that would be worked, so that students could get ahead in the search for knowledge, the so-called flipped classroom. For this purpose, images, animated videos, and manual activities were used, such as mental maps, organized to provide familiarization with the theme and interest in active participation. Thus, the idealization of the flipped classroom, as well as interactive slides, maps, cards containing challenges and a puzzle, were resources designed to improve problem-solving skills.

After delimiting the topics covered in the activity, the group decided, for playful purposes, to set the activity in the Harry Potter universe, since it is a well-appreciated series by the target audience. During the elaboration of the maps used in the dynamics, the Geogebra software was used as a support. Once the maps were created, they were hosted together with the game tracks on the Quizlet platform. Given the need to create more interactive and visually attractive slide presentations, PowerPoint was use as well.

After developing the game, as well as the lesson support material, texts and videos related to the topic of vectors were organized so that the participants could become familiar with the subject, in order to provide greater engagement on the day of the activity. The difficulties encountered were mainly related to the distribution and management of tasks, given the small number of monitors involved in the elaboration and execution of the activity, as well as the search for virtual tools, such as software that met the demands that arose, while they were of course, accessible to all participants. In this sense, the extended time spent in planning and surveying material is interpreted as natural, with the consequent impact of a greater number of tests among the team.

At the end of the activity, it was observed that, although successful and well accepted among the target audience, the game needed modifications so that better gameplay was achieved. The vulnerabilities found were mainly reflected in the execution time. Due to the high number of topics raised on vectors and their operations, the theoretical presentation lasted an average of one and a half hour, requiring constant revision, since one of the objectives of the game was to perform calculations. As for the level of difficulty of the issues raised, in specific points they went beyond what is usually included during high school, constituting, therefore, one of the flaws identified by the team. Regarding the reception of students at the workshop, students' feedback was considered positive. However, participation and involvement with the texts and videos previously provided through the flipped classroom was markedly low, which resulted in losses to the interaction among group members. Such occurrence was observed especially in the first meeting, which aimed not only to explain the main points of the theoretical content, but also to acclimatize the students to the platforms that would be used.

Workshop on batteries and cards: activities related to electricity

Following the vector workshop, two activities specific to the STEM areas were planned and carried out in 2020, both related to electricity, with the common characteristic of adopting the hands-on methodology, an approach previously used face-to-face and of notorious importance within the Fast Girls project.

The first workshop carried out within the context of electrical charges in flux consisted of the production of a galvanic cell, a device capable of generating electrical energy from a chemical reaction, thus dealing with the content of electrochemistry. Its unfolding, thus, culminated in an experimental activity that used as a teaching-learning method the investigation of phenomena. In addition to the usual slide shows and flipped classroom, materials were provided to students - among which were copper coins, galvanized washers, and an LED, which made it possible to carry out the experiment through a videoconference with the monitors who set up a copper-zinc battery, therefore turning on an LED through an oxidation reaction. As it is a content with a high degree of abstraction, since it alludes to the subatomic universe, a simulation platform was used to illustrate the experiment known as the Daniel battery to stimulate the students' curiosity before the beginning of the theoretical exposition, resulting in a better understanding of the activity proposed. Due to the low adherence to the theoretical material separated for the vector workshop, a gymkhana was organized, where the activities were individually carried out before and during the workshop, activities based on the texts and videos presented in the flipped classroom. The student with most points at the end of the activity was rewarded with a prize. In this sense, the participants answered a questionnaire on the topics covered in the previously sent

document, when they were instructed to do a research on how the subject of electrochemistry is related to the phenomena observed in daily life.

In turn, the second workshop of this thematic group focused on electrical circuits, in which the elaboration of decorated cards was used as a didactic tool. Using LEDs, conductive tape and 3V battery, an electrical circuit was set up on paper; the responsible monitors guided the students throughout the process in a videoconference during the workshop. Searching for greater simplicity, part of the materials provided consisted of papers and decorative items, so the participants were able to decorate the card according to their individual preferences, resulting in a wide variety of prints and showing a relaxed atmosphere when exhibiting the final products from the activity. Due to the complexity of the content covered, the elaboration of mind maps was suggested. They are information management diagrams that allow a broader view and faster understanding of the subject. During this workshop, the use of the Mentimeter was also introduced, a tool that allowed the application of a questionnaire during the presentation with feedback in real time. It enabled the group to identify with precision and agility the students 'vulnerabilities in theoretical terms.

Regarding the planning and execution of activities, the monitors, undergraduate students, prepared the lesson plan, experiments and other activities taught, though project administrators were the ones responsible for the purchase and distribution of materials.

As these were experimental activities, the main challenges were related to the tests performed, given the distance between the monitors and the consequent difficulty in replicating them with alternative materials. The execution, however, took place smoothly, so that the technical objectives initially proposed, such as greater engagement and collaboration of the participants during the theoretical explanation, were fully achieved.

4 Tools for evaluation and analysis of results

In this section it will be present qualitative results based on the views of the monitors and the undergraduate students about the workshops held. To this end, a questionnaire was prepared for the monitors and also a questionnaire for each workshop held, with the objective of obtaining feedback from the high school students in order to improve the activities and overcome the difficulties encountered.

A total of 7 monitors, undergraduate students from the exact area answered the questionnaire intended for them. The group of high school students participating in the project in 2020 consisted of 14 girls aged 15 to 17. Four students answered the questionnaires for the electric circuits workshop and 13 students answered the questionnaires for the batteries workshop.

In the form sent to the high school students there were questions regarding the performance of the workshop, the content taught, the clarity of the explanations, the topics that should have been explored more, space for praise and criticism.

In addition, to complement the information obtained in the monitors' questionnaire, it was also conducted an interview with the project monitors, who reported that one of the main problems encountered during the adaptation to the new context was the demand for the development of workshops that had the same quality and interactivity as before. The interview took place in early April 2021.

4.1 Monitor's view

From the analysis of the questionnaires sent to the monitors it was found that around 71.4% of the monitors had not had contact with remote education previously, which required greater dedication in elaborating solutions for a little experienced environment.

Among the problems identified in the elaboration of solutions, there was the interaction difficulty between the monitors and students, the difficulty of internet and electronic devices access and doubts about the type of workshop that could be offered, being the adaptation of a face-to-face workshop to a remote one, the most challenging of all measures.

Replacing face-to-face workshops with remote ones brought problems related to the elaboration of these practices, and to how the contents previously given in the classroom would be approached. As a result, its development became more time-consuming and challenging, since it was necessary to assess problems that could occur - such as the failure of the software to be used and the difficulty of students accessing the programs - in addition to the need to think of a model class that involved the participants, resulting in, among other aspects, the overload of those responsible for the activities. The monitor´s level of encouragement in giving workshops was questioned. That ranged from 1 to 5, in which 1 was seen as the worst level of motivation and 5 the most satisfactory and it was observed that most of the monitors preferred the face-to-face teaching model, as the data collected in the interview show that 57% of the monitors chose to score 5, when referring to doing the face-to-face activities, while, at a remote level, only 14% of the interviewees opted for this alternative.

In relation to the time spent in the elaboration of the workshops, it was observed that over time the monitors became more agile, since they gradually gained experience with this class model, with the problems that could arise in the workshops and, therefore, the period of elaboration of activities was shortened.

Interaction difficulty between monitors and students was also a potential generator of problems, as it could cause greater demotivation of monitors executing the workshops.

In view of the new requirements, it was observed that the tutors acquired and developed multiple skills in the face of the challenges encountered, such as: the development of more suited classes to the profile of students (adapted to be both expository and practical), creativity , imagination, teamwork (since the workshops were designed by a group of monitors), organization, logical reasoning, critical thinking, the ability to solve problems, as well as greater flexibility and mastery of virtual resources, for example.

4.2 High school student´s view

After analysing the questionnaires sent to the high school students, we were able to obtain a general feedback of the workshops, as well as opinions and criticisms. Thirteen students answered the battery workshop questionnaire, nine of whom had never studied galvanic cells, and four students answered the electric circuits workshop questionnaire.

At the end of the workshops and after analysing the forms sent to the students, it was observed that the strategies adopted during the execution of the activities reached the expected goals of motivating the students with a new way of presenting and working with contents.

Regarding the use of colorful and fun slides during the class, all thirteen respondents approved the quality of the presentation. The interactive theoretical presentation of the battery workshop lasted less than an hour and all students agreed that the subjects covered, galvanic cells, electrolytic cells, ox reduction reactions, batteries, and electric current were adequate for the proposed experiment. The time was also considered adequate for them to learn without getting too tired. For the electric circuits workshop all students also considered the time adequate.

Most of the students reported that they felt more motivated by the hands-on activities, with the experiments performed in the battery and electrical circuit workshops. Regarding theory and the concepts taught, all reports indicated that these contributed to the understanding of the practical part of the workshop. In this sense, comments such as "I was very excited to make a battery" and "it generated more interest in the content taught in the slides" were some of the messages received, and it can be concluded that the theoretical and practical teachings complemented each other.

The hands-on discovery of how simple objects from our everyday life work, be it a battery or an electric circuit, and the sharing of this experience on social networks has maintained the students' interest in STEM subjects even after the end of the workshops. All of the students reported that the most interesting part of the workshop was related to the hands-on, and some of them pointed out that they would like all the activities to keep this format, thus confirming the potential of hands-on activities to motivate students' learning even when the activities are done remotely.

The adoption of the flipped classroom aims to reduce the content presentation time, and the competition in the form of a gymkhana held in the battery workshop proved to be an effective engagement tool. Twelve of the thirteen students present on the day of the synchronous activity viewed the material previously sent. This strategy was adopted because, in the previous workshop on vectors, we noticed a lack of interest from the students in accessing the contents previously. The use of alternative engagement strategies, such as games and competitions may be interesting for this purpose.

5 Conclusion

Considering what was exposed in this article, we may conclude that even in a totally new and sudden scenario for all, active learning strategies proved to be effective for remote teaching. Despite the difficulties and obstacles encountered along the way, we were able to conclude the project´s main objective during the Covid-19 pandemic: to continue the project so that the workshops would remain with quality and attractiveness.

It appears that active learning strategies are a good alternative to ensure that the student remains focused for almost the entire class, since, unlike traditional teaching methods, the student is encouraged to establish communication with the monitor. Strategies such as flipped classroom and hands-on activities have been shown to be effective regarding a dynamic class, and efficient in terms of learning, involving the student before, during and after the workshop. Such strategies proved to be ideal to close the gap between monitors and students, in addition to reducing the lack of motivation to workshops attendance.

Therefore, due to the good results obtained, the project will continue to be based on active learning strategies aimed at remote education throughout the period that social isolation endures, in an attempt to bring to online workshops, the proximity and interaction previously adopted in presential encounters, in addition to enabling higher interest in learning.

Acknowlegments

To *Fundação de Apoio a Pesquisa* (Research Support Foundation) of the Federal District, FAP – DF, to Dex/UnB and to CNPq for financial support. To *Centro de Ensino Médio* 404, CEMEB and CEF 201 for the partnership and pedagogical support to students in the Project.

6 References

Ananiadou, K. and M. Claro (2009), "21st Century Skills and Competences for New Millennium Learners in OECD Countries", OECD Education Working Papers, No. 41, OECD Publishing. <http://dx.doi.org/10.1787/218525261154>

Barreto, A. (2014). A mulher no ensino superior: distribuição e representatividade. Cadernos do GEA, 6, 5-46.

Corlu, M. A., & Aydin, E. (2016). Evaluation of learning gains through integrated STEM projects. International Journal of Education in Mathematics, Science and Technology, 4(1), 20-29.

Costa, A. R., Batista, F. A., Santos, L. P. C., Oliveira, M. J. A. D., Viana, D. M., Silva, J. Y. M. A. D., ... & Koike, C. M. C. (2020). Capacitação de tutores para estratégias de aprendizagem ativa nas áreas de STEM.

Costa, A. R., Batista, F. A., Santos, L. P. C., Oliveira, M. J. A. D., Viana, D. M., Silva, J. Y. M. A. D., ... & Koike, C. M. C. (2020). Tutoria e múltiplas abordagens em oficina de modelagem e impressão 3D.

Felder, R. M. & Brent, R. (2009). Active Learning: An Introduction. ASQ Higher Education Brief, 2, 1-5.

Prince, M. J. & Felder, R. M (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. Journal of Engineering Education. 123-138.

Srinath, A. (2015). Active Learning Strategies: An Illustrative Approach to Bring out Better Learning Outcomes from Science, Technology, Engineering and Mathematics (STEM) Students. International Journal of Emerging Technologies in Learning, 10.

Tucker, B. (2012). The flipped classroom. Education next, 12(1), 82-83.

Ziegelmeier, L. B., & Topaz, C. M. (2015). Flipped calculus: A study of student performance and perceptions. Primus, 25(9-10), 847-860.