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# The Use of the Station Rotation Model to Enhance Science Achievement in Secondary Education: A Systematic Review

## Modelo Rotación por Estaciones para la mejora del rendimiento en ciencias en secundaria: una revisión sistemática

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### Abstract

*The emergence of the COVID-19 pandemic and the implementation of the Organic Law of Education (LOMLOE) in Spain have prompted the adoption of new teaching approaches oriented towards a more competency-based and digital methodology. In this context, the Station Rotation Model is seen as an innovative approach with the potential to effectively facilitate the acquisition of key competencies. The main objective of this study is to determine the essential characteristics that the Station Rotation Model should have to enhance the acquisition of scientific and digital competencies in secondary education. For this purpose, a systematic review has been conducted, including the analysis of 21 studies relevant to this model and its conclusions. The research results emphasize the importance of solid, organizational, pedagogical, and technological planning to promote an interactive, engaging, and personalized learning environment, while highlighting the ability of the Station Rotation Model to enhance science learning. The main discussion focuses on identifying the characteristics that the Station Rotation Model should have in order to achieve*

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*success in the acquisition of scientific and digital competencies in secondary education, as well as on detecting the main difficulties to avoid or minimize them as much as possible. Finally, the aim is to determine the relevance of implementing this model.*

*Keywords:* blended learning; station rotation; secondary education; science education.

## Resumen

*La aparición del COVID-19 y la implementación de la Ley Orgánica de Educación (LOMLOE) en España, ha impulsado la adopción de nuevos enfoques de enseñanza orientados a una metodología más competencial y digital. En este contexto, el modelo de Rotación por Estaciones se posiciona como una propuesta innovadora, con el potencial de facilitar de manera efectiva la adquisición de competencias clave. El objetivo principal de este estudio es determinar las características fundamentales que debe tener el Modelo de Rotación por Estaciones para potenciar la adquisición de competencias científicas y digitales en educación secundaria. Para ello, se ha realizado una revisión sistemática que incluye el análisis de 21 estudios relevantes para este modelo y sus conclusiones. Los resultados de la investigación subrayan la importancia de una buena planificación organizativa, pedagógica y tecnológica para promover un entorno de aprendizaje interactivo, atractivo y personalizado, y destacan la capacidad del Modelo de Rotación por Estaciones para mejorar el aprendizaje científico. La discusión principal se centra en fijar las características que debe tener el Modelo de Rotación por Estaciones para alcanzar el éxito en la adquisición de competencias científicas y digitales en la educación secundaria, así como en la detección de las principales dificultades, para evitarlas o minimizarlas en la medida de la posible. En último término, se pretende determinar la pertinencia de implantación de este modelo.*

*Palabras clave*: *blended learning*[2]; rotación por estaciones; educación secundaria; enseñanza de ciencias.

## Introduction

The emergence of COVID and compulsory confinement in a large part of the world's countries has highlighted the need to study the efficiency of distance and blended teaching-learning modalities (Gil et al., 2021). In addition, the increasing relevance of digital technology in society and education, including the use of the Internet, has enabled the creation of virtual environments, which has prompted the adoption of more personalised teaching approaches to meet the needs of learners (Alam and Agarwal, 2020; Govindaraj and Silverajah, 2017; Xiangze and Abdullah, 2023). On the other hand, the teaching-learning processes of the 21st century require teachers to transform their educational practice from a traditionally more knowledge-centred approach (Buskets et al., 2016) to a more learner-centred approach. In this new approach, students take on a more active role, which encourages the development of critical thinking and reduces

[2] *Blended Learning* o modelo combinado (en adelante BL)

problems common in traditional models, such as inattention (Azizan, 2010). Traditional educational practice is characterised by placing the teacher as the central figure in the classroom, with the main role of presenting content, using methods such as the master class and direct teaching.

According to Ausubel (2000), in traditional teaching, the lack of explicit connection between new content and students' prior experiences can limit the effectiveness of learning. This is because knowledge is often presented in isolation, without considering how it relates to the students' everyday reality and context. On the other hand, when students are in the process of learning, relating new information to what they already know and understanding its relevance, learning is long-lasting. Therefore, it is imperative that teachers explore and adopt more effective educational approaches in their classrooms (Graham, 2013).

Science teaching in the Spanish context is facing new challenges, many of which are subject to Organic Law 3/2020. This educational reform highlights the importance of orienting teaching towards the promotion of practice and learning through competences, equipping citizens with the ability to interpret the world (Domènech-Casal and Marbà-Tallada, 2022). Among scientific competences, mathematical competence and competence in science and technology, also known as STEM (*Science, Technology, Engineering and Mathematics*) competences, stand out, in line with the principles supported by the Sustainable Development Goals (SDGs) within the framework of the 2030 Agenda (Sanahuja and Tezanos, 2017).

Point three of article 4 of Organic Law 3/2020, of 29 December, which modifies Organic Law 2/2006, of 3 May, on Education (LOMLOE), states that when the diversity of students so requires, the relevant organisational, methodological and curricular measures will be adopted, in accordance with the principles of Universal Design for Learning (UDL), facilitating access to the support that students require. In this context, and in the face of current challenges, it is necessary for educational institutions to consider methods that not only address these competences, but are also flexible and able to adapt to the needs of learners (Müller and Mildenberger, 2021). According to the literature, the BL model could be a solution to this new approach, as it offers an adaptive environment that can facilitate the acquisition of these competences (Gil et al., 2021), while providing opportunities to acquire digital skills and develop autonomy in their learning (Sulisworo et al., 2020), which fosters more active and collaborative learning, thus increasing student motivation and engagement (Ardianti et al., 2020).

The BL model is a modality that integrates traditional face-to-face learning with distance or virtual learning (Alsalhi et al., 2019; Minhas et al., 2021) agree that this fusion is an effective way to optimise the learning process. In a BL environment, students participate in a face-to-face classroom, but also have access to online resources and activities to supplement their learning (Sivakumar and Selvakumar, 2019). This is effective in supporting students facing difficulties in complex and challenging subjects such as physics, chemistry or mathematics by leveraging technology to enhance the educational experience (Larsary et al., 2023).

There are several types of *Blended Learning* (BL) models, among which four main rotation approaches stand out: Station Rotation, Lab Rotation, *Flipped Classroom* and Individual Rotation (Ayob et al., 2020). Each of these models has particular characteristics, although they share the integration of at least one online learning station.

Among these models, the Station Rotation model is particularly versatile, as it combines a virtual work station, a collaborative work station and a station for direct interaction with the teacher. This flexible structure is closer to the individual needs of the students (Tupas and Linas-laguda, 2020). By working in small groups and moving between activities within the classroom, the model encourages active learning and the acquisition of competences in a dynamic way (Othman et al., 2018).

The BL model works with the advantages of the face-to-face and virtual modalities, without their limitations (Usart, 2020), being, according to a study implemented in the United States in educational centres that focuses on evaluating and improving the effectiveness of the BL approach, called *Basics-Blended Learning Universe* (BLU) (2018, 2 May) (Figure 1), the most used model to work in the first years of secondary education as it allows students to have more personalised attention in the classroom (Akinoso et al, 2021).

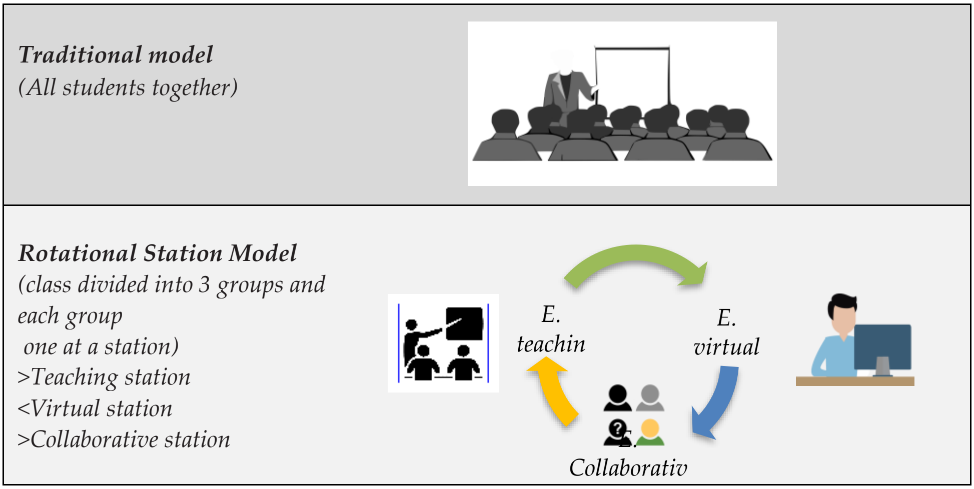
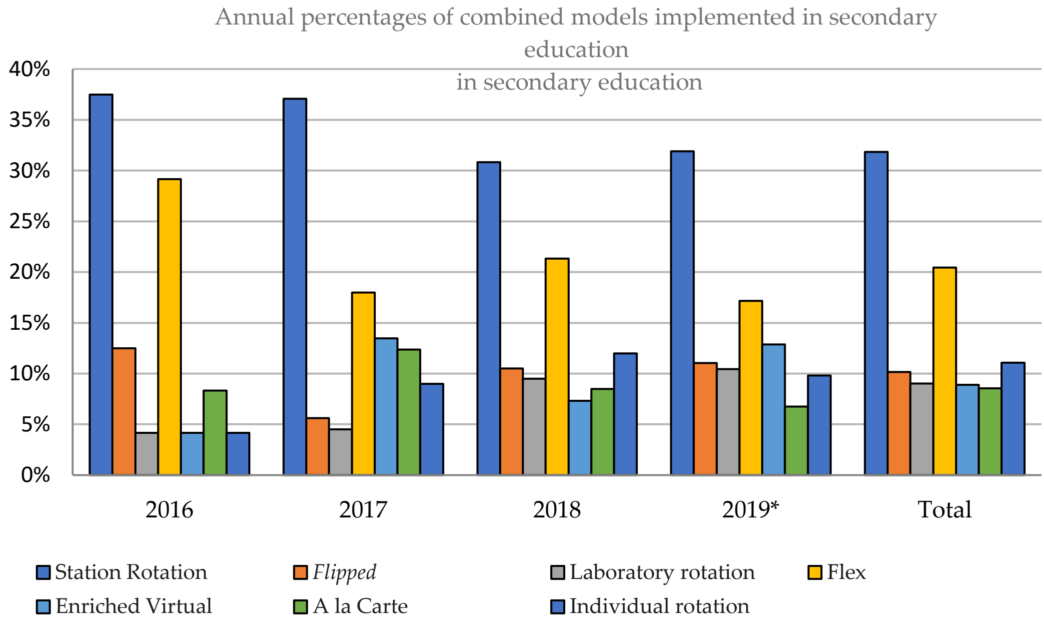



*Figure 1*. Traditional Model and Seasonal Rotation Model (Own elaboration)

In the study by Gil et al. (2021), the Station Rotation model is the most widely used in lower secondary education, with a significant evolution in recent years (Figure 2). When examining the results generated by the BLU Study, it can be seen that the MRE and the Flexible Model have generated the most data in that specific order.

Unlike the Station Rotation model, where activities are structured and tailored to the duration of the session, the Flex model relies primarily on online learning, with face-to-face interventions only when support is needed (Graham, 2013).




*Note:* *All data are annual except for 2019 as data were only recorded up to September. Prepared by the authors based on BLU data (2016).

*Figure 2*. BL mode implemented in teachings in the USA during 2016-2019.

It is interesting to note that the use of these models varies depending on the educational level and the course in which the BL is applied. The order of preference of the models by educational level (1 most preferred; 7 least preferred) is presented below, with those numbered 1 and 2 being the most popular (Table 1).

Table 1

*Order of preference of BL models by educational stage*

| **Educational level** | **Flex** | A la carte | Enriched Virtual | **Station rotation** | Laboratory rotation | Individual rotation | Inverted classroom |
|---|---|---|---|---|---|---|---|
| Children's | 3 | 6 | 4 | **1** | 2 | 5 | 7 |
| education | 3 | 7 | 6 | **1** | 2 | 4 | 5 |
| Primary | 2 | 7 | 5 | **1** | 5 | 3 | 4 |
| education | **1** | 4 | 2 | 3 | 7 | 6 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1st and 2nd ESO** | **1** | 4 | 2 | 3 | 7 | 6 | 5 |
| 3rd and 4th ESO | | | | | | | |
| Baccalaureate and VET | | | | | | | |

*Note:* Table adapted from Gil et al. (2021).

Numerous research studies have demonstrated the benefits of this model in terms of motivation, student engagement and academic achievement, compared to both purely online and traditional face-to-face teaching (Akinoso et al., 2021; Da Silva et al., 2023; Larsari et al., 2023). On the other hand, researchers such as Müller and Mildenberger (2021) argue that the flexibility of this model could be the key to understanding academic achievement, especially in comparison with more traditional teaching approaches. For all these reasons, and taking into account that in the context of Secondary Education there are hardly any literature reviews on the Station Rotation Model that allow for a detailed analysis of its benefits or limitations, the need to review studies on this particular teaching model arises.

## Methodology

The present research has been carried out by means of a Systematic Literature Review (SLR), which involves reading the scientific literature, with the purpose of identifying studies that apply the station rotation model in secondary education. This methodology has been chosen to provide a comprehensive overview of previous evidence on the topic, which could not be obtained with other methodologies, such as case studies or isolated experimental designs, as they do not offer such a broad and comprehensive perspective of the existing picture. Given the limited number of specific articles on this model at this level of education, the search is extended to include other *Blended Learning* models that are implemented in the same courses or that may provide relevant answers to the research questions posed. This extension includes complementary approaches that, while not exclusively corresponding to the station-based rotation model, share key features that contribute to the objectives of the study

The criteria of the PRISMA declaration (Urrútia and Bonfill, 2010) have been followed for a correct elaboration, structuring the review in three well-differentiated moments or phases:

- *Phase 1:* preliminary search of the scientific literature in the field of study using specific keywords.
- *Phase 2:* filter the identified articles, applying previously established relevance criteria.

- *Phase 3:* qualitative content analysis of the papers selected in the previous phase, in order to address the questions posed at the beginning of the process. In this phase, a detailed review of the 21 selected studies is carried out (Nowell et al., 2017), allowing the information to be organised in a structured way to extract key information from the reviewed studies. Following the review, the data from the 21 studies are compared and disaggregated (Maykut and Morehouse, 1994).

## Search procedure

In order to effectively guide the SLR, direct the search and facilitate the drawing of conclusions, the following key question is formulated:

- Q1. What are the essential characteristics of a combined approach based on MRE in order to be effective in the acquisition of scientific competences in the context of secondary education?

The aim is to identify the key features of the station-based rotation model (SRM) that enhance the acquisition of science competences in secondary education, in alignment with the objectives of the LOMLOE, in order to optimise students' academic performance. From this main question, the following secondary questions arise to address more specifically and in detail the area of study:

- Q2. What is the effect of using the MRE on improving student achievement in science at the secondary school level?
- Q3. How does the adoption of MRE, which integrates organisational, pedagogical and technological dimensions, influence the effectiveness of the acquisition of mathematics, science and technology competences in an educational environment?

This approach seeks to identify quality research that provides relevant and up-to-date evidence on the effectiveness of this model and the essential characteristics it must possess to be a successful model.

The literature search is conducted in the three most widely used scientific databases in education: ERIC, Scopus and *Web of Science*, known for hosting quality peer-reviewed journal articles, reports, conference papers and books in the educational field. These databases are widely recognised for their rigorous review process and broad coverage of scholarly literature, ensuring the inclusion of relevant and reliable studies. The articles selected are from relevant, high-impact journals in the field of study. This ensures that the data and conclusions are based on research published in high quality and reputable sources, thus ensuring the robustness and relevance of the systematic review.

The search is carried out using the following keywords and Boolean operators: (*blended learning** OR *flipped classroom** OR *hybrid education** OR *inverted education**) AND (*secondary school** OR *intermediate school** OR K12) AND (STEM OR *science**).

### Inclusion and exclusion criteria

The inclusion and exclusion criteria for the SLR articles (Table 2) include those articles published in the last 10 years due to the need to provide an updated view of the state of the art on the topic in question. In addition, other relevant studies have been incorporated which, although not specifically on SLR, offer valuable information to address key aspects of the research questions.

Table 2

*Criteria for inclusion of SLR*

| Criterion | Inclusion | Exclusion |
|---|---|---|
| Type of educational model | Station Rotation or BL | Traditional, Internet and online learning. |
| Publication period | 2013-2023 | Before these dates |
| Language of publication | Spanish, English and Portuguese | Other languages |
| Context of the study | Secondary education, sciences | Other levels of education and other subjects |
| Type of publication | Article, free access | Do not be articles or open |
| Design and implementation | Case studies | Systematic reviews |

*Note:* Table prepared by the authors

After agreeing on the inclusion and exclusion criteria, as well as determining what information is extracted from the publications, the databases are filtered. Table 3 shows the percentage of articles found in each of the databases.

Table 3

*Filters obtained according to database and key words*

| Header | WOS | | SCOPUS | | ERIC | | TOTAL |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n |
| Articles | 478 | 16,09% | 1464 | 49,29% | 1028 | 34,61% | 2970 |

*Note:* Table prepared by the authors

In the analysis of the SLR considering keywords as a reference, a total of 2970 documents are identified in the different databases. After applying exclusion criteria, such as limiting the search to open access articles from the last 10 years in English, Spanish or

Portuguese, a final result of 461 relevant documents was obtained. Subsequently, duplicates were eliminated and the documents were screened after review of titles, abstracts and full content, yielding a final result of 21 articles (Figure 3).

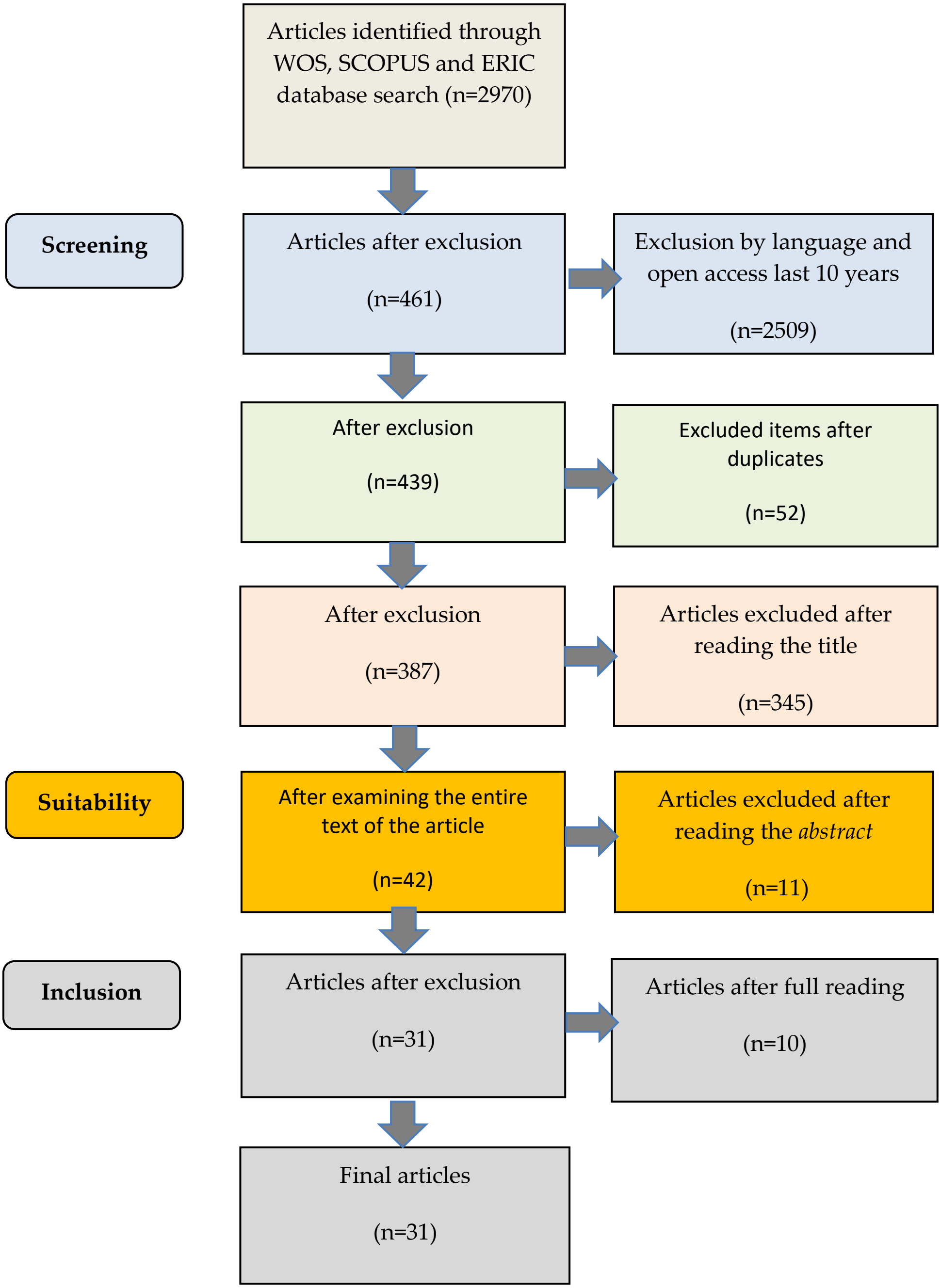



Figure 3. Diagram of article selection developed based on PRISMA (Urrútia and Bonfill, 2010).

The papers resulting from the SLR have been arranged in chronological order, as detailed in Table 4. From these articles, information has been extracted on the country where the study is conducted, the research approach, the sample size and the results obtained. All articles are contextualised in Secondary Education as this is an inclusion criterion.

On the other hand, the research question has been taken into account when analysing them. Therefore, the presentation of results and their analysis is structured around this question, focusing on the organisational, technological and pedagogical dimension of all successful experiences.

## Results

After analysis of the 21 articles, it is important to note that, despite the limited data at both international and national levels, there is a notable increase in the production of papers during 2020, coinciding with the emergence of the COVID-19 pandemic (Figure 4).

This increase is attributed to the widespread implementation of BL models that allow home-based learning, a measure adopted in response to the confinement restrictions. The need for a flexible methodology became particularly evident during such confinement, leading to the widespread adoption of blended learning approaches to ensure continuity of learning in the event of similar future restrictions.

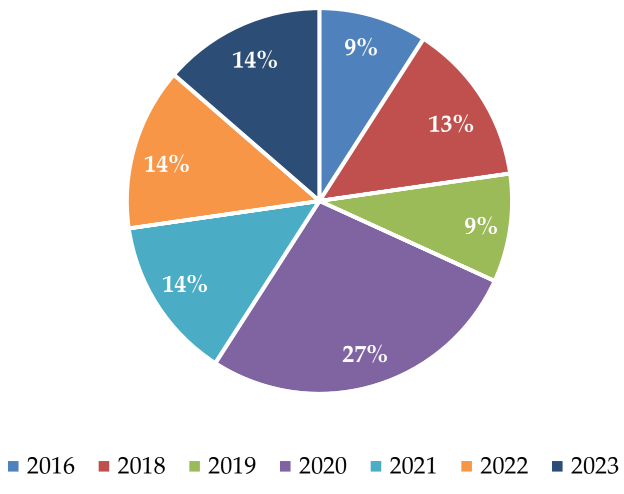



*Figure 4*. Own elaboration. Selected sample of publications by year of publication.

In relation to the number of participants, an average of 82 participants per study, of which 25% adopted qualitative and 29.17% quantitative approaches, including quasi-experimental designs. Experimental designs accounted for 4.16% and exploratory designs for 8.30%. The origin of the studies was 17.4% for the United States, Indonesia (21.74%), and Brazil, Malaysia and the United Arab Emirates (8.7%). In addition, 4.34% of studies were identified in Canada, Hong Kong, India, Nigeria, Philippines, Serbia, Spain and Taiwan.

The analysis of the selected papers is carried out in two stages. First, the articles are reviewed and classified according to the educational level at which the blended learning model is implemented, the country of origin to consider the context, the type of study, the sample used (size and characteristics) and the main results of each research. This is followed by a more in-depth analysis in terms of the three research questions posed:

- The essential features of the study and the benefits or drawbacks of the study are identified;
- The impact of the model applied in the study on performance improvement is then examined;
- and finally, it assesses how the integration of the organisational, pedagogical and technological dimensions of the study influence performance.

Detailed information is presented in Table 4 with the results of each investigation.

Table 4

*Summary and Analysis of 24 Scientific Productions on BL Models of Teaching in Secondary Education*

| NO. | Reference | Educational level | Country | Type of study | Sample | Results |
|---|---|---|---|---|---|---|
| 1 | Kwong and Churchill (2023) | Secondary education | Hong Kong | Qualitative | 8 students aged 12-13. | Integration of the e-Portfolio in a science classroom with Google Sites over two BL teaching and learning courses yields positive results. It adds recommendations for implementation in MYP classrooms. |
| 2 | Mutya and Masuhay (2023) | Secondary education | Philippines | Quantitative | 182 students and 12 science teachers | The study investigates the extent of BL implementation in secondary school science education in terms of content, communication, technology, pedagogy and assessment. Better results by grouping students according to profile. Positive effects on the academic performance of science students when implementing BL. |
| 3 | Radulović et al. (2023) | Secondary education | Serbia | Quasi-experimental design (g. control and experimental). | 128 secondary school students aged 16 | Relationship between students' motivation to learn physics and the role (passive or active) in the learning process. The teacher's role as facilitator and the students' participation in the BL model improve their self-efficacy and the value they place on learning physics. |
| 4 | Xiangze, and Abdullah (2023) | Secondary education VET | China | Qualitative | 32 students | The results of the research revealed significant effects on improving student engagement in three dimensions: cognitive, emotional and |

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| | | | | | | behavioural. Increased interest in learning English. Key themes were identified as "Improved autonomy", "Improved achievement", "Digital competence with mobile learning", willingness to make an effort, self-efficacy and communicative competence. |
| 5 | Viana et al. (2023) | Secondary education | Brazil | Qualitative | 12 students in 3rd year of ESO | The use of the MRE in confinement had as positive points the development of learner autonomy and the use of diverse strategies in a creative environment. |
| 6 | Bacelais et al. (2022) | Secondary education | Canada | Quantitative | 74 students (36 in the treatment group and 38 in the control group). | The results of the study suggest that the use of robust questionnaires and peer feedback in a BL learning context improves STEM education (better long-term retention and longer lasting learning outcomes). |
| 7 | Cheng et al. (2022) | Secondary education | Taiwan | Quasi-experimental (pre- and post-test) | 39 students (16-17 years old) | In the study, the effectiveness of a BL learning approach that intersperses educational games with physical experiments in science was evaluated. The educational game used, "Scialience", proved to be effective in improving students' understanding of the content and retention. |
| 8 | Da Silva et al. (2023) | Secondary education | Brazil | Qualitative descriptive. | 28 students Two inclusive education students | The rotational station model is applied. With careful planning and organisation of a timetable, this collaborative approach contributes to more effective and enriching teaching. |

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|---|---|---|---|---|---|---|
| 9 | Akinoso et al. (2021) | Secondary education | Nigeria | Quasi-experimental design (pre- and post-test) | 120 students (61 with the rotation model and 59 with traditional methodologies) | use of robust quizzes and peer feedback in a BL learning context enhances STEM education (better long-term retention and more lasting learning outcomes). |
| 10 | Ayob et al. (2021) | Secondary education | Malaysia | Quantitative | 17 fourth grade students | The Station Rotation model helps students learn chemistry in a fun way. |
| 11 | Minhas et al. (2021) | Secondary education | United Arab Emirates (UAE) | Qualitative | 16 teachers | The results highlight that BL benefits students with diverse needs. Challenges are identified, such as the need for more thorough planning and increased workload. The importance of student motivation and continuous teacher training are underlined as crucial factors for the success of BL. |
| 12 | Ardianti et al. (2020) | Secondary education | Indonesia | Quantitative | Five classes, with 27 students each | The study (physics lessons in schools in rural areas) found that BL learning with the STEM education approach improved students' critical thinking more effectively than conventional learning. |
| 13 | Gunawan et al. (2020) | Secondary education | Indonesia | Quantitative | 29 science teachers | Intelligent tutoring systems enhance science teaching in a BL learning environment by providing personalised support. ITS (Intelligent Tutoring Systems) can help create innovative learning in various fields of education. Limits: requires high costs, risks and some planning at school level. |
| 14 | Sulisworo et | Secondary | Indonesia | Quasi- | 30 students using | Studies conclude that both *Google Classroom* |

| | | | | | | |
|---|---|---|---|---|---|---|
| | al. (2020) | education | | experimental design (pre- and post-test) | *Google Classroom* and 26 using Schoology | and *Schoology* are effective platforms for implementing BL and improving students' critical thinking skills. |
| 15 | Tayag (2020) | Secondary education | Philippines | Qualitative | 5 teachers and 60 students | BL can improve the quality of education by providing a more flexible and personalised learning environment. It is recommended to provide sufficient pedagogical support, adequate spacing, alignment of online and face-to-face activities and knowledge of skills for assigned tasks. |
| 16 | Alsalhi et al. (2019) | Secondary education | United Arab Emirates | Case study with quasi-experimental design. | 112 students, (experimental group 61 and control group 51) | The BL model improves the results (better performance and more positive attitudes) in scientific competence in 3rd ESO students. |
| 17 | Sivakumar and Selvakumar (2019) | Secondary education | India | Experimental (pre-post test) | 40 students (21 men and 19 women) | The study recommends the BL approach to physics learning to improve performance and retention among secondary school students. |
| 18 | Truitt (2018) | Secondary education | USA USA | Qualitative | 31 students | The results reveal five positive themes when using the MRE (variety of activities, technology, learning, fun and helpfulness) and two negative themes (difficult work and technology). They performed better on brainstorming, introspection, organisation, accuracy and fluency. The data also indicated somewhat higher levels of language learning. |
| 19 | Utami, (2018) | Secondary | Indonesia | Quantitative | 63 students aged 15- | The BL contributes to improving student |

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|---|---|---|---|---|---|---|
| | | education | | | 16 years (31 g. experimental and 32 g. control). | performance in the subject of information and communication technology. *Quizziz* application for assessment. |
| 20 | Sulisworo et al. (2016) | Secondary education | Indonesia | Quantitative quasi-experimental design, | 62 students (30 in the control group and 32 in the treatment group) | Students taught using cooperative learning in physics had higher learning achievement than those taught with traditional learning. |
| 21 | Whiteside et al. (2016) | Secondary education | USA USA | Exploratory design (mixed method) | 5 principals, 18 teachers, 264 students in groups of 26 pupils and 62 parents | Valuing independent learning, time management, self-regulation, encouraging enquiry and relationship building. Preparation for university |

*Note:* Table prepared by the authors

The following table specifies the results of quantitative studies on the use of either the MRE or the BL model, depending on the model, in science subjects in secondary education.

Table 5

*Results of quantitative studies measuring the effectiveness of the use of BL in secondary education in science.*

| NO. | Reference | Results |
|---|---|---|
| 5 | Bacelais et al. (2022) | Participants in the treatment group had a significant improvement in final exam scores compared to the control group, with a significant mean difference of 7.63 points. |
| 9 | Ayob et al. (2021) | Significant improvement in student performance in the BL learning classroom, with an increase in mean scores from pretest to post-test from 62.65 to 69.41. The *Wilcoxon Signed-Rank* test confirms this improvement as statistically significant ($Z=-2.143$, $p<.05$), demonstrating the effectiveness of the Station Rotation model in BL learning. |
| 11 | Ardianti et al. (2020) | The study investigates critical thinking skills in students, using tests consisting of ten essay questions with 27 participants. Only five questions were considered valid, and test-retest reliability was moderate (0.419). Normality and homogeneity tests confirm that the data come from a homogeneous population. Before the experiment, the experimental and control groups showed similar prior knowledge. After the intervention, the experimental group obtained a significantly higher mean score in critical thinking skills (81.5) compared to the control group (60.6). ANCOVA analysis revealed that the STEM educational approach to BL learning had a significant effect on the development of critical thinking skills ($p < 0.05$), indicating that the learning strategy significantly influenced students' critical thinking skills. |
| 12 | Gunawan et al. (2020) | It analyses 29 science lesson plans, highlighting the effectiveness of learner-centred activities and the integration of technology in developing higher-order thinking skills. The plans cover curriculum integration in biology, chemistry and physics, with an emphasis on hands-on learning and the development of critical and creative skills. |
| 18 | Utami (2018) | The study investigates the effect of the BL model on the academic performance of secondary school students, compared to traditional teaching. Pre-intervention results showed no significant differences between the experimental and control groups, indicating similar levels of knowledge. However, post-tests reveal a significant improvement in the performance of the experimental group, with an average of 82.5 compared to 72.9 for the control group, demonstrating the effectiveness of BL learning. |
| 19 | Sulisworo et al. (2016) | The study shows that the group of students participating in Moodle technology-assisted cooperative learning shows a significant increase in their grades, with the average grade increasing from 74.2 in the pre-test to |

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|---|---|---|
| | | 82.6 in the post-test. This result was significantly higher than that of the control group, which followed a traditional teaching method, whose average grades only increased from 73.6 to 76.8. It suggests that the integration of educational technologies and cooperative learning not only benefits academic performance, but also students' attitudes towards learning. |
| 20 | Whiteside et al. (2016) | It concludes that blended learning not only helps students feel more prepared for university, but also enhances key skills such as self-regulation, enquiry and relationship building. A variety of instruments are used to collect data, including surveys, interviews, focus groups and classroom observations. In total, the study included 5 administrator interviews, 18 teacher surveys and 12 teacher interviews, 264 student surveys, 62 parent surveys, 2 parent interviews, and observations and reviews of additional teaching materials. |

*Note:* Table prepared by the author. BL: *Blended Learning*

Based on the analysis of the selected studies, key factors for the effective design of a BL model have been detailed (Table 6), which can serve as a guide for the proper implementation of the BL model called "Seasonal Rotation".

Table 6

*Key factors to take into account in designing the ERM*

| Dimension | Summary | Studies |
|---|---|---|
| Organisational dimension | Need for different stations, to multiply learning, encouraging participation and reducing distractions. | Viana et al. (2023)<br>Ayob et al. (2021)<br>Gil et al. (2021)<br>Mutya and Masuhay (2023) |
| | Need for time management and flexibility in space. Combination of face-to-face and online activities. | Whiteside et al., (2016)<br>Da Silva et al., (2023)<br>Xiangze and Abdullah (2023) |
| Pedagogical dimension | Formative evaluation that considers interaction, feedback, affective state, and performance. | Utami (2018) |
| | Selection of learning materials and resources | Alsalhi et al. (2019) |
| | Adaptation of the contents to the needs of the students. | Sulisworo et al. (2016)<br>Xiangze and Abdullah (2023) |
| | Collaborative learning, participation, feedback and formative assessment. Practical, varied and challenging, but achievable activities, and applying them to real-world situations. | Alsalhi et al. (2019)<br>Arddianti et al. (2020)<br>Gunawan et al. (2020)<br>Sulisworo et al. (2016)<br>Radulović et al. (2023) |

| | | |
|---|---|---|
| | | Utami (2018) |
| | Importance of teacher training | Minhas et al. (2021) |
| Technological dimension | Use of different data sources | Utami (2018) |
| | Technological tools for feedback, self-regulation and autonomy (tools such as Microsoft Forms, Google Forms and in LMS, Moodle, Sakai, Blackboard, Scialience). | Cheng et al. (2022)<br>Kwong and Churchill (2023)<br>Mutya and Masuhay (2023)<br>Sivakumar and Selvakumar, (2019)<br>Suliswor o et al. (2020) |
| | Creating an inclusive environment | Tayag (2020) |
| | It allows for better visualisation and repetition of phenomena, helps with the degree of abstraction. | Akinoso et al. (2021)<br>Radulović et al. (2023)<br>Sulisworo et al. (2020) |

*Note:* Table prepared by the authors

## Discussion and conclusions

According to the existing literature, the fusion of face-to-face and e-learning, known as BL, has emerged as an effective strategy for raising the quality of education at the secondary level. From the review, the robustness of this approach is evident in a variety of research in science subjects (Ayob et al., 2021; Cheng et al., 2022; Radulović et al., 2023; Sivakumar and Selvakumar, 2019; Sulisworo et al., 2016), which shows that the BL model has a positive impact on both achievement and knowledge retention. This research is in line with previous research such as Graham (2013) and Müller and Mildenberger (2021).

Addressing the general objective (Q1) of the research, in terms of the strengths of the model, according to Truitt (2018), the adoption of ERM brings with it positive issues such as the use of technology to aid learning and the motivation of students to interact more with each other and with the teaching staff, as well as the benefits of having more personal feedback (Bacelais et al., 2022; Da Silva et al., 2023; Sulisworo et al., 2016; Viana et al., 2023) to aid learning. On the other hand, it also presents challenges such as increased individual and collaborative work and technological distraction (Tayag, 2020). The effectiveness of MRE, as highlighted by Govindaraj and Silverajah (2017), is enhanced by student participation in varied activities that enhance their learning experiences. The inclusion of digital technologies (Viana et al., 2023) and simulators (Cheng et al., 2022; Gunawan et al., 2020; Kwong and Churchill, 2023; Radulović et al., 2023; Sivakumar and Selvakumar, 2019; Sulisworo et al., 2020) contributes significantly to this enriched environment.

Regarding the effect on student achievement (Q2): Akinoso et al. (2021) and Ardianti et al. (2020) highlight how MRE transforms teaching and learning, offering access to a wider range of activities and promoting the development of scientific skills such as critical thinking.

On the other hand, to answer the third question (Q3), the literature indicates that the integration of organisational (timetables), pedagogical (interdisciplinarity) and technological (with adequate infrastructure) dimensions must be taken into account (Da Silva et al., 2023). Likewise, Mutya and Masuhay (2023) highlight the importance of grouping students according to their profile in collaborative groups in order to achieve good results. Likewise, Minhas et al. (2021) add that communication is crucial for the model to be effective, which validates the presence of the teaching station where more attention is given to students. Finally, the implementation of the BL model requires a need for teacher training (Gil et al., 2021; Gunawan et al., 2020). If we compare the MRE model with other combined models, the MRE model is more suitable for the first years of Compulsory Secondary Education than other BL models (Gil et al., 2021), due to its organisation (within the classroom and with a specific timetable) and dynamism (Zakaria et al., 2010), as other models such as the *flipped classroom* (Quispe et al., 2010) are more suitable for the first years of Compulsory Secondary Education (Gil et al., 2021),

2021), require responsible learners to do homework at home (Govindaraj and Silverajah), which in very low grades is not always the case.) Students often believe that traditional classrooms are more effective than online combinations (Alam and Agarwal, 2020), which reaffirms the relevance of this particular model in the early years of ESO, compared to other blended models, as it is entirely classroom-based.

Despite all these benefits, the implementation of MRE faces significant limitations. Technological distraction (Ayob et al., 2021), difficulty in content and risk of addiction to gamification from the virtual station (Xiangze and Abdullah, 2023), student and teacher resistance to change and workload (Whiteside et al..., 2016), difficulties in knowing the keys to the various virtual applications (Truitt and Ku, 2018), appropriate spacing of activities (Whiteside et al., 2016), difficulties in knowing the keys to the different virtual applications (Truitt and Ku, 2018), appropriate spacing of activities (Tayag, 2020) are recurrent problems that underline the need for more effective supervision and guidance by teachers. Therefore, Da Silva et al. (2023) suggest a gradual implementation and adaptation to the structural reality of the school taking into account the organisation of timetables to improve the effectiveness of the station-based rotation model (SRM).

In conclusion, despite the many limitations noted in the studies, we believe that the benefits of applying this model outweigh its limitations. Therefore, we recommend further research in classroom settings to evaluate its effectiveness. It is crucial to use efficient evaluation systems, such as surveys and observation rubrics, as well as pre- and post-tests, to measure the results after the implementation of the model.

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