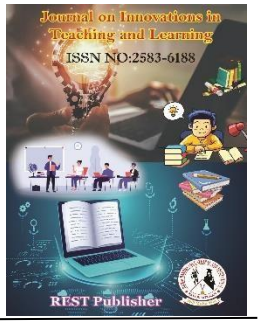
Journal on Innovations in Teaching and Learning
Vol: 2(1), March 2023
REST Publisher; ISSN: 2583-6188 (Online)
Website: http://restpublisher.com/journals/jitl/
DOI: https://doi.org/10.46632/jitl/2/1/4



Blended Learning Quality Measurement System using DEMETAL Method

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Abstract: *A learning approach called blended learning combines in-person and online instruction. To achieve learning goals, blended learning successfully combines synchronous and asynchronous learning settings. Indicators that are live, virtual, autonomous, synchronous, and cooperatively asynchronous are all used in this study. A methodology is required to come up with suggestions for how to implement blended learning more effectively because there are various indicators that may be used to measure its effectiveness. Online collaborative learning activities are increasingly being used thanks to cloud computing. Despite the inclusion of a specific online application or service, it is not clear how different cloud computing technologies have impacted the concept of collaborative learning or how widely these resources are now accessible to students. The review's conclusions revealed a number of justifications in support of employing particular cloud computing technologies for tasks related to collaborative learning that are categorized as sharing, editing, communication, and discussion. Face-to-face, problem-based, online, independent, collaborative, and evaluated tasks are all considered evaluation criteria. The DEMETAL approach, which was utilized in this study, can deal with data that is imprecise and inaccurate. The relative importance of each blended learning indicator is established using the DEMETAL method. The aim of this work is to provide methodology for decision support systems that provides recommendations for putting blended learning into practice. Problem-based learning, task collaboration, and autonomous tasks are those components of blended learning that have the greatest impacts, according to the research. The test findings revealed that task collaboration with a first rank is cause and effect produced the highest accuracy.*
Keywords: *DEMETAL method, Blended learning, network teaching platform*

1. INTRODUCTION

Blended learning is a practice that combines traditional face-to-face instruction with online learning elements. To provide students with a comprehensive and flexible learning environment, it blends the best features of both in-person and online education. In a blended learning setting, students participate in a variety of in-person and online learning activities, often through a learning management system (LMS) or other online platforms. The introduction of blended learning has been driven by advancements in technology and a recognition of the benefits that both traditional and online learning methods can offer. It aims to leverage the strengths of each approach to enhance student engagement, personalize learning experiences, and promote active participation. In a typical blended learning model, students may attend in-person classes for certain subjects or activities while utilizing online resources for others. The online component can include a variety of learning materials such as interactive multimedia content, online discussions, virtual simulations, and self-paced modules. This allows students to access learning materials anytime and anywhere, fostering flexibility and convenience. Blended learning offers several advantages. It allows for a more individualized and self-paced learning experience, enabling students to progress at their own speed and revisit concepts as needed. It also provides opportunities for interactive and collaborative learning, as students can engage in discussions and group projects both in-person and online. Furthermore, it can enhance the development of digital literacy skills and familiarity with online tools, which are increasingly important

in today's digital world. However, implementing blended learning effectively requires careful planning and design. Educators need to select appropriate online resources, create engaging and interactive online activities, and ensure seamless integration between in-person and online components. Additionally, ongoing monitoring and assessment of student progress are essential to ensure that learning goals are being met. Overall, blended learning offers a dynamic and flexible approach to education, blends the benefits of in-person interaction and online learning. It has the potential to enhance student engagement, promote personalized learning, and prepare students for the digital age. Blended learning process: The teaching approach in a regular classroom is teacher-centered; The usual teaching format "speaking-listening-reading-memorizing-practicing" [3], that is homogeneous and frequently separates theory from practice. The "learning" is the focus of the teaching process in Internet-based online instruction, which distinguishes "teaching" from "learning" [4]. When students have the freedom to learn independently at a time and place that works for them, passive learning transforms into active learning. Because it is difficult for the teacher to keep track of the students' learning progress, in an online learning environment, the teaching process is more disjointed and there is ineffective communication between the teacher and the pupils. Blended learning mixes traditional classroom training with online instruction to fully realize their benefits. The teacher can instruct and manage the class, but the students can also take the lead in their own independent learning. The practice of education appears to involve a wide range of blended learning strategies that are applied at various organizational levels. Successful hybrid teaching, according to Percy and Cramer, "cannot be a mishmash of traditional lecture with some online content, but rather a thoughtful re-design of program pedagogy, and meaningful interactions with students." The idea under discussion was developed using the author's expertise in teaching, as well as cutting-edge organizations and educators in this field, general methodological concepts, and computer programming methodology. The modifications didn't affect the course's goals, the number of hours of instruction, or where the subject was on the curriculum [8]. The development of internet-based online teaching technologies might accelerate the educational process, but these developments are often only possible after careful pedagogical design. Simply merging existing face-to-face and online learning methodologies does not always result in a noticeable gain of learners' knowledge since the several models in Graham's style need to be carefully applied to specific learning objectives [10]. Blended learning connotations: At the moment, experts domestically and internationally have various interpretations of what blended learning means. By examining and researching relevant literature from both domestic and international sources, blended learning, which combines the traditional teaching model with modern networks and computer technology, takes full advantage of their advantages and, in the end, produces the best portfolio of various teaching elements in the teaching profession, according to research. Well-structured and uncontrolled learning, in addition to learning, practice, and performance support, are all components of blended learning. Additionally, a wide range of instructional materials, learning environments, and educational theories are included [2]. Instead of merely disseminating information, design education aims to build understanding through project-based activities completed in studio and non-studio courses. Many design fields of study, including the fields of industrial design, architecture, interior architecture, and urban design, promote a studio environment as the optimum learning environment since they all rely on group problem-solving, cooperation, and problem-based learning. During conversations about interior architectural design, individuals can come up with different solutions to design issues while also exchanging knowledge and information. Giving students the freedom to select their own experiences will enhance their academic performance and promote higher order social interaction, thinking, and reasoning skills.

2. MATERIALS AND METHODS

For both teachers and students, blended learning encourages more adaptable, interactive, effective, accessible, and diverse learning. The concept of blended learning involves combining traditional classroom instruction with current technology-assisted learning techniques. At every level of education, assessment is a crucial tool for determining the subject-matter understanding of students. Using blended learning strategies, instructors can offer lectures and evaluate students' learning in novel and creative ways. The advantages of using blended learning methodologies in the educational system are the main idea of this article. Along with this teaching technique, assessment strategies are covered in this publication. The blended learning approach is highly intriguing since it combines online and in-person learning in a more thorough way [6]. The following are the synchronous and asynchronous learning settings that make up the features of blended learning when employing a constructive approach: Live Synchronous, Virtual Synchronous, Asynchronous Standalone, and Asynchronous Collaboration. The four indications of the quality of blended learning that are examined here are live synchronous, virtual synchronous, autonomous asynchronous, and collaborative asynchronous. Live synchronous learning includes face-to-face interactions, problem-based learning techniques, lectures, exercises, conversations, presentations, and other activities. Virtual synchronous learning,

which includes video conferences, audio conferences, and chat, takes place simultaneously in the same or various room dimensions. By using technology to participate in online learning, Live synchronous is expanded upon by virtual synchronous. Independent asynchronous learning: Students can learn independently using printed materials such as books, magazines, and modules in a variety of spatial and temporal contexts (at anytime and anywhere). Asynchronous collaborative: Offers students and teachers the option to debate, look at, research, and assess issues related to online learning content. It includes project work, mailing lists, and discussion forums. Table 1 displays data for the list of operations for each indicator utilized in the following. Since using technology to support collaborative learning plans needed thinking about modifying the traditional teaching approaches, it was discovered that faculty members' low technology competence was the main barrier to using synchronized tools in online collaborative learning (Schneckenberg et al., 2011). A few examples of this include the absence of effective means of boosting communication, member contributions that are balanced, and mutual support. Some group members may feel that even if they did not make the paper they read or edited worse, Blau and Caspi (2009) suggest that this is a possibility, others' ideas may have had a detrimental effect on the caliber of their work. In order to efficiently create and manage the learning system, technicians must also become familiar with the cloud architecture (Tan & Kim, 2011) [9].

The skill-driven integrated learning method on the "integrated network teaching platform," developed by the Educational Technology Department of Tsinghua University and made available, a skill-driven blended learning pattern system for instruction has been designed. The system fully engages the students' interest by integrating a number of learning modalities, learning media, learning platforms, and learning environments, including network remote learning in addition to face-to-face instruction. A skill-driven learning strategy combines online teacher supervision with independent study. This combination is an example of an efficient blended learning pattern that can help students feel less alone and enable them to successfully perform autonomous learning tasks. In addition to developing support for blended learning and practice, the educational system also produces guidelines for autonomous learning, so that both theory teachers and experiment teachers can use it to assess their pupils [11]. Though it is not very widespread in computer engineering, in many other professions, problem-based learning (PBL) has proven to be an extremely effective educational strategy. By encouraging student participation, PBL goes above and beyond the conventional teaching methods. Although PBL has many different uses, it is always characterized by three key elements: group work as a stimulant for interaction, tutors as facilitators, and challenges as a learning stimulus. PBL advocates contend that because it is founded on four cutting-edge conceptions of learning—constructive, self-directed, collaborative, and contextual—it can better prepare kids for future learning. The model's critics, however, came to the conclusion that PBL was very expensive and that graduates revealed they lacked the ability to reason like experts and may have had significant gaps in their cognitive knowledge [12].

TABLE 1. Evaluation Parameters

Face to Face	C1
Problem Based Learning	C2
Learning Methods	C3
Online	C4
Independent Task	C5
Task Collaboration	C6
Task Evaluation	C7

C1: Face to Face - This refers to a learning or communication method where individuals are physically present in the same location, allowing for direct interaction and non-verbal cues.
C2: Problem Based Learning - This is an educational approach that focuses on solving real-world problems. Students are presented with a problem or scenario and work collaboratively to identify and solve the problem, applying their knowledge and critical thinking skills.
C3: Learning Methods - This generally refers to the various approaches, techniques, or strategies used to facilitate learning. It can include different instructional methods, such as lectures, discussions, demonstrations, group work, or hands-on activities.
C4: Online - This refers to activities or resources that are conducted or accessed via the internet. Online learning often involves digital platforms, virtual classrooms, and web-based tools for delivering educational content and facilitating interactions.

C5: Independent Task - This refers to a task or assignment that is completed by an individual on their own, without direct collaboration or assistance from others. It requires self-direction and self-motivation to complete the task successfully.
C6: Task Collaboration - This involves working together with others to accomplish a task or complete an assignment. It can involve sharing ideas, dividing responsibilities, and leveraging the strengths and expertise of each team member to achieve a common goal.
C7: Task Evaluation - This refers to the process of assessing or judging the quality, performance, or outcome of a task or assignment. It typically involves criteria or rubrics to evaluate the work and provide feedback or grades based on predefined standards or expectations.

The MCDM (Multi-Criteria Decision Making) DEMETAL (Determination of the Most Effective Factors in Teaching and Learning) method is an approach used in educational research to identify and prioritize the most effective factors in teaching and learning processes. It is a decision-making method that helps researchers and educators evaluate and rank various factors based on their impact on teaching and learning outcomes.
The DEMETAL method typically involves the following steps:

1. Identification of Factors: We identify pertinent variables that may affect student learning and teaching outcomes. These factors can include teaching methods, instructional materials, student engagement, assessment strategies, classroom environment, and others.
2. Criteria Definition: Criteria are established to evaluate the effectiveness of each factor. These criteria can be specific learning outcomes, student performance, student satisfaction, engagement levels, or any other measurable indicators of teaching and learning effectiveness.
3. Data Collection: Data is collected on each factor and criteria through surveys, observations, interviews, or other research methods. This data can be quantitative or qualitative, depending on the nature of the factors and criteria.
4. Weighting and Evaluation: The collected data is analyzed, and weights are assigned to each factor and criterion based on their relative importance and impact on teaching and learning. "Various MCDM techniques such as Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), or Weighted Sum Model (WSM) can be used to calculate the weights and evaluate the factors".
5. Ranking and Decision-Making: The factors are ranked based on their weighted scores or overall performance. The ranking helps identify the most effective factors in teaching and learning. This information can guide educators and policymakers in making informed decisions and implementing strategies to enhance teaching and learning outcomes.

The MCDM DEMETAL method provides a systematic and structured approach to identify and prioritize the factors that significantly contribute to effective teaching and learning. It helps researchers and educators focus their efforts and resources on areas that have the greatest impact on student success and educational outcomes.

3. RESULT AND DISCUSSION

TABLE 2. Data Set

	C1	C2	C3	C4	C5	C6	C7	Sum
C1	1	0.2	0.33	0.99	0.14	0.11	0.33	3.1
C2	5	1	3	5	0.33	0.2	3	17.53
C3	3	0.33	1	3	0.2	0.14	0.99	8.66
C4	0.99	0.2	0.33	1	0.14	0.11	0.33	3.1
C5	7	3	5	7	1	0.33	5	28.33
C6	9	5	7	9	3	1	7	41
C7	3	0.33	0.99	3	0.2	0.14	1	8.66

The table represents the pairwise similarity or correlation values between different variables (C1, C2, C3, C4, C5, C6, and C7) in the data set. The last column, "Sum," seems to represent the sum of the similarity values for each row.

TABLE 3. Normalized Data

	C1	C2	C3	C4	C5	C6	C7
C1	0.0353	0.00706	0.0116	0.03495	0.00494	0.00388	0.01165
C2	0.17649	0.0353	0.1059	0.17649	0.01165	0.00706	0.10589
C3	0.10589	0.01165	0.0353	0.10589	0.00706	0.00494	0.03495
C4	0.03495	0.00706	0.0116	0.0353	0.00494	0.00388	0.01165
C5	0.24709	0.10589	0.1765	0.24709	0.0353	0.01165	0.17649
C6	0.31768	0.17649	0.2471	0.31768	0.10589	0.0353	0.24709
C7	0.10589	0.01165	0.0349	0.10589	0.00706	0.00494	0.0353

The values in this table have been normalized, which typically means that they have been scaled to fall within a specific range (such as 0 to 1) or transformed in a way that makes them comparable. In this normalized table, each cell represents the normalized value between two variables (C1, C2, C3, C4, C5, C6, and C7) in the data set. The values are now decimal numbers between 0 and 1. Table 2 values taken as Y values.

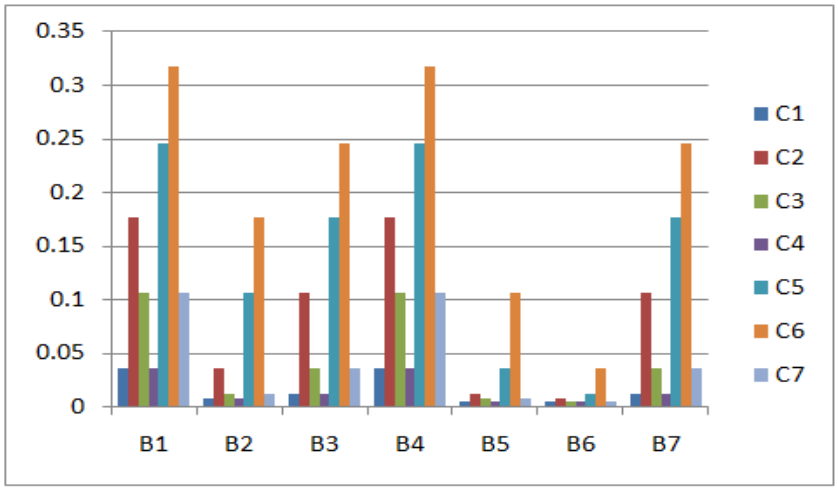

FIGURE 1. Normalized Data

The values in this figure 1 have been normalized, which often implies that they have been modified to make them comparable or scaled to fall within a certain range (such as 0 to 1).

$$T= Y (I-Y)-1$$

In the context of decision-making and analysis, the identity matrix is represented by I, the normalized data matrix by Y, and the total relationship matrix by T. The equation T = Y (I - Y)^(-1) is a mathematical formulation used to calculate the Total Relation matrix.

TABLE 4. I= Identity Matrix

1	0	0	0	0	0	0
0	1	0	0	0	0	0
0	0	1	0	0	0	0
0	0	0	1	0	0	0
0	0	0	0	1	0	0
0	0	0	0	0	1	0
0	0	0	0	0	0	1

The table 3 provided above represents an identity matrix, commonly denoted as "I." A square matrix that has all of its off-diagonal and diagonal entries equal 1 is known as an identity matrix. One of the variables or dimensions in the data collection is represented by each row and each column. The diagonal elements (top-left to bottom-right) have values of 1, demonstrating perfect correlation between each variable and itself. The off-diagonal elements, which are all 0, indicate that there is no correlation between different variables.

TABLE 5. (I-Y)

C1	0.964702	-0.00706	-0.01165	-0.0353	-0.00494	-0.00388	-0.01165
C2	-0.17649	0.964702	-0.10589	-0.17649	-0.01165	-0.00706	-0.10589
C3	-0.10589	-0.01165	0.964702	-0.10589	-0.00706	-0.00494	-0.0353
C4	-0.0353	-0.00706	-0.01165	0.964702	-0.00494	-0.00388	-0.01165
C5	-0.24709	-0.10589	-0.17649	-0.24709	0.964702	-0.01165	-0.17649
C6	-0.31768	-0.17649	-0.24709	-0.31768	-0.10589	0.964702	-0.24709
C7	-0.10589	-0.01165	-0.0353	-0.10589	-0.00706	-0.00494	0.964702

The table 4 provided above represents the result of subtracting matrix Y from the identity matrix (I - Y). Each cell in the table contains the corresponding value after performing the subtraction. In this table, each row and column still corresponds to the variables or dimensions in the data set. The values in each cell represent the subtraction result for the corresponding elements of matrix Y from the identity matrix. The resulting values reflect the deviation or difference between each variable and the corresponding variable in matrix Y. This can be interpreted as a measure of dissimilarity or the extent to which the variables differ from their expected values in the given context.

TABLE 6. (I-Y)-1

C1	1.0472	0.0100	0.0173	0.0472	0.0065	0.0047	0.0173
C2	0.2375	1.0473	0.1317	0.2375	0.0182	0.0111	0.1317
C3	0.1331	0.0176	1.0471	0.1331	0.0103	0.0069	0.0471
C4	0.0472	0.0100	0.0173	1.0472	0.0065	0.0047	0.0173
C5	0.3613	0.1292	0.2277	0.3613	1.0472	0.0188	0.2277
C6	0.5117	0.2214	0.3408	0.5117	0.1279	1.0474	0.3408
C7	0.1331	0.0176	0.0471	0.1331	0.0103	0.0069	1.0471

In this table 5, each row and column correspond to the variables C1, C2, C3, C4, C5, C6, and C7 in the data set. The values in each cell represent the inverse of the corresponding elements in the matrix (I - Y). Taking the inverse of the matrix (I - Y) allows us to find the original matrix Y. The values in this table can be interpreted as similarity or correlation measures between the variables, demonstrating the depth of their connections. A stronger association is shown by higher values, whilst a weaker relationship is indicated by lower values.

TABLE 7. Total Relation matrix (T)

C1	0.04718	0.010007	0.017349	0.04718	0.0065	0.004734	0.017349
C2	0.237546	0.047287	0.131706	0.237546	0.01823	0.011146	0.131706
C3	0.133132	0.017565	0.047125	0.133132	0.010344	0.00693	0.047125
C4	0.04718	0.010007	0.017349	0.04718	0.0065	0.004734	0.017349
C5	0.361263	0.129186	0.227651	0.361263	0.04725	0.018831	0.227651
C6	0.511694	0.221369	0.34078	0.511694	0.127872	0.047364	0.34078
C7	0.133132	0.017565	0.047125	0.133132	0.010344	0.00693	0.047125

In this table 6, each row and column correspond to the variables C1, C2, C3, C4, C5, C6, and C7 in the data set. The values in each cell represent the total relation between the corresponding variables. The values in this table indicate the overall relationship or correlation between variables, taking into account all the interactions among them. Higher values suggest stronger relationships, while lower values indicate weaker relationships. The Total Relation matrix (T) provides a comprehensive view of the relationships between variables in the data set, incorporating both direct and indirect relationships.

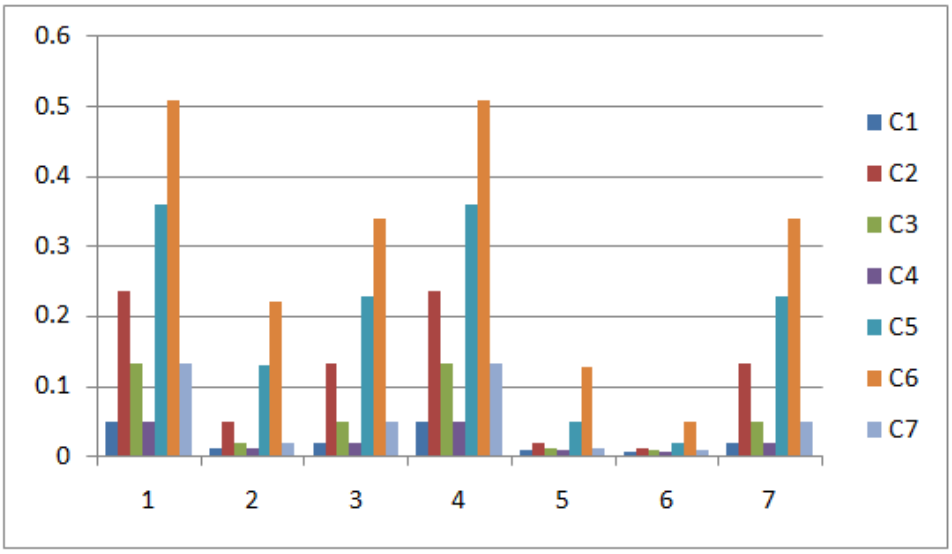

FIGURE 2. Total Relation matrix (T)

In Figure 2, the Total Relation Matrix (T) is depicted provides a comprehensive view of the relationships between variables in the data set, incorporating both direct and indirect relationships.

TABLE 8. Ri and Ci

	Ri	Ci
C1	0.150299	1.471127
C2	0.815168	0.452987
C3	0.395353	0.829085
C4	0.150299	1.471127
C5	1.373097	0.227042
C6	2.101553	0.10067
C7	0.395353	0.829085

In this table, each row corresponds to a variable in the data set (C1, C2, C3, C4, C5, C6, C7). The "Ri" values represent the Row Importance, which indicates the relative importance or significance of each variable in relation to other variables in the data set. Higher values of Ri suggest that the corresponding variable has a stronger influence or importance in the analysis. The "Ci" values represent the Column Importance, which indicates the relative importance or significance of each variable in relation to other variables in the data set. Higher values of Ci suggest that the corresponding variable is more influential or important in the analysis. These Ri and Ci values can be used to assess the importance of variables and prioritize them based on their impact in various analyses or decision-making processes.

TABLE 9. The Cause and Effect By Calculating Ri+Ci, Ri-Ci and Rank

	Ri+Ci	**Ri-Ci**	**Rank**	**Identity**
Face to Face	1.621425	-1.32083	2	effect
Problem Based Learning	1.268154	0.362181	5	cause
Learning Methods	1.224437	-0.43373	6	effect
Online	1.621425	-1.32083	2	effect
Independent Task	1.600138	1.146055	4	effect
Task Collaboration	2.202223	2.000883	1	cause
Task Evaluation	1.224437	-0.43373	6	effect

The "Ri+Ci" column represents the sum of the Row Importance (Ri) and Column Importance (Ci) values for each variable. It indicates the overall importance or influence of the variable in the analysis. The "Ri-Ci" column

represents the difference between the Row Importance (Ri) and Column Importance (Ci) values for each variable. It shows the relative balance between the row and column effects. The "Rank" column represents the ranking of the variables based on their Ri+Ci values. A rank of 1 is given to the variable having the highest Ri+Ci value, indicating its higher importance compared to other variables. The "Identity" column specifies whether the variable is considered an "effect" or a "cause" based on its characteristics and impact in the analysis. These additional columns provide further insights into the relative importance, effects, and relationships among variables in the data set.
The analysis of the variables reveals interesting insights into their importance, effects, and ranks.

Task Collaboration emerges as the most influential factor with a combined Ri+Ci value of 2.202223, earning it the top rank of 1. This indicates that Task Collaboration plays a significant role and acts as a cause in the context being studied. Its high Ri+Ci value suggests that it has a strong influence on other variables. Face to Face and online both share a Ri+Ci value of 1.621425 and hold the rank of 2. They are identified as effect variables, meaning they are influenced by other factors in the analysis. Despite having the same Ri+Ci value, they may have different Ri-Ci values, suggesting a potential difference in their individual impacts. The variable Independent Task holds a Ri+Ci value of 1.600138, placing it in the fourth rank. It is also classified as an effect variable. While its influence is slightly lower than Task Collaboration and the Face to Face/Online variables, it still holds significant importance in the analysis. Problem Based Learning exhibits a Ri+Ci value of 1.268154, earning it the fifth rank. It is identified as a cause variable, meaning it has an impact on other factors. Its positive Ri-Ci value indicates a stronger row effect than column effect, emphasizing its role in driving the analysis. Learning Methods and Task Evaluation both share a Ri+Ci value of 1.224437, placing them in the sixth rank. These variables are categorized as effect variables, indicating that they are influenced by other factors rather than causing significant effects themselves.

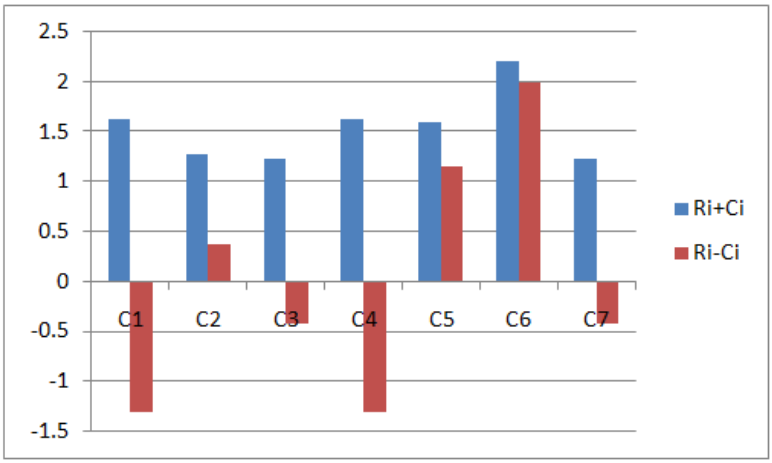

FIGURE 3. Ri+Ci and Ri-Ci

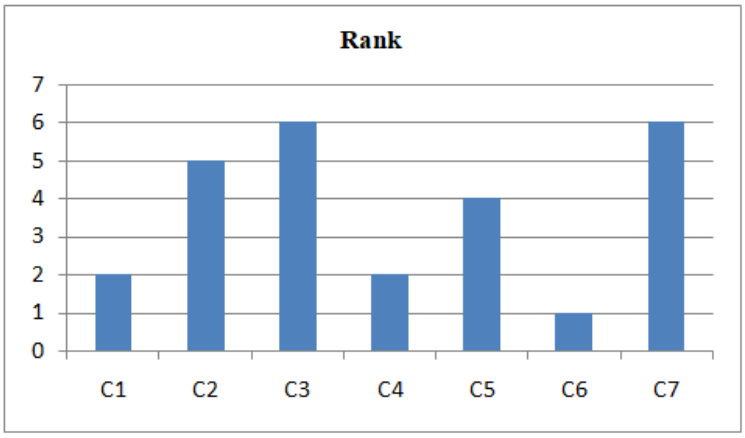

FIGURE 4. Ranking

Figure 4 shows Face to Face is second rank, Problem Based Learning is fifth rank, Learning Methods is sixth rank, Online is second rank, Independent Task is fourth rank, Task Collaboration is first rank, and Task Evaluation is sixth rank.

4. CONCLUSION

A teaching strategy known as blended learning mixes traditional in-person instruction with online learning activities. It has gained significant popularity in recent years, and its effectiveness has been widely studied and recognized. In conclusion, blended learning offers several benefits and advantages. Firstly, it provides flexibility and convenience for both students and teachers. Learners can access course materials and resources online at their own pace, allowing them to study at a time and place that suits them best. Teachers can also leverage online tools and platforms to create interactive and engaging learning experiences. the analysis highlights Task Collaboration as the most influential variable, acting as a cause in the studied context. Face to Face, Online, Independent Task, Problem Based Learning, Learning Methods, and Task Evaluation are identified as effect variables, each playing a distinct role in the analysis. These findings provide valuable insights into the relationships and relative importance of the variables in the given context.

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