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APPLYING CENTRALITY MEASURES TO THE COURSE PREREQUISITE NETWORK ANALYSIS OF THE UNDERGRADUATE CIVIL ENGINEERING CURRICULUM

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Abstract. This study utilized graph theoretical analysis to examine the undergraduate curriculum of the Civil Engineering (BSCE) program at the university by constructing and evaluating its Course Prerequisite Network (CPN) representation. The curriculum is modelled as a directed graph with vertices denoting courses and directed edges connecting courses having prerequisite relations, and then analyzed using centrality measures, specifically, degree centrality, betweenness centrality, and eigenvector centrality, to identify pivotal courses that play critical roles in student academic progression. Using the Social Network Visualizer (SocNetV) software, the researchers constructed the CPN and examined the curriculum's structural relationships. The analysis revealed that CE Project 1 Laboratory (T-CEET413LA) consistently ranked highest across all centrality measures, establishing its primary role in the curriculum. Its position within the curriculum emphasizes its influence as both a capstone and a bridge course, connecting foundational subjects to advanced specializations. The findings provide curriculum designers, educators, and students with quantitative insights into course significance and sequencing, contributing to more coherent, efficient, and learner-focused academic planning within the civil engineering program.

***Keywords**:* centrality measures, curriculum, curriculum design, network, prerequisites.

1. Introduction

In recent years, the Philippine education system has experienced significant changes resulting from the implementation of the K-12 basic education reform, conceptualized in 2010, legislated under the Republic Act No. 10533, and fully implemented in 2016. This legislation fundamentally altered the preparedness profile of incoming college and university students [1]. The transformed basic education curriculum, which added two years to high school through the introduction of the Senior High School (SHS), has demanded that higher education institutions (HEIs) redesign their own academic programs, particularly regarding curriculum revision. General education subjects previously taken in the first two years of college were now moved to the senior high school, compelling HEIs to undertake major changes in the curriculum to reduce duplication of content, focus more on specialized and research-oriented coursework, and enhance global competitiveness and relevance [2], [3]. Aside from the mandatory changes necessitated by the K-12 curriculum, internationalization activities, ASEAN integration, and the global mobility of Filipino graduates required a curriculum that would consistently meet international standards for degree comparability and employability [4]. These factors, along with evolving industry demands, underscore the need for a systematic and regular curriculum review.

A crucial component of the design of any academic program relies on its curriculum, as it represents the flow of knowledge that students must acquire to earn their degree. However, limited quantitative analysis has been conducted on curricula to investigate interactions and relationships existing among courses, or to identify the most pivotal courses. According to Lightfoot [5], graph theoretical modelling is an effective tool in curriculum design and analysis, where course prerequisites can be presented as a directed graph, and then its academic structure can be evaluated for efficiency. The Course Prerequisite Network (CPN) analysis, which is grounded in mathematical graph theory, provides a powerful, evidence-based framework and quantitative basis for guiding curriculum review. A CPN provides a visual representation of the curriculum using a graph, where courses are represented as nodes or vertices, while prerequisite relationships among courses are reflected as directed edges. It helps educators and curriculum designers visualize knowledge flows from basic to advanced courses and determine which courses function as sources, integrators, or bridges [6].

Higher education institution administrators and educators can utilize mathematically supported insights drawn from network-based models such as CPN as a basis for designing curricula focused on optimal sequencing and alignment of course offerings, proper delivery of content, provision of intervention and support to facilitate students in aid of program completion, and improving overall efficiency and coherence of the program [7], [8]. When applied consistently, CPN analysis provides a sustainable strategy for curriculum review. It transforms the process into a proactive exercise that yields continuous improvement, ensuring Philippine HEIs' academic programs remain pedagogically sound, structurally efficient, and globally competitive. Among university programs, engineering degrees are among the most in demand, but simultaneously are the most difficult ones to complete [9]. They require aptitude in mathematics, sciences, and logic, as well as strong critical thinking and problem-solving skills. In the country, undergraduate engineering programs also have a higher number of units and requires more terms to finish compared to other programs. These programs consist of mathematics, physical sciences, engineering sciences, professional courses, and general education courses. The complexity of the academic structure exhibited by the engineering curricula suggests they could benefit significantly from CPN analysis. Implementing CPN analysis in engineering curriculum design ensures a logical and efficient sequence of courses, thereby enhancing educational outcomes and optimizing resource allocation [10], [11]. At the university where the study was conducted, the college offering engineering programs has the highest student population specifically, the Bachelor of Science in Civil Engineering (BSCE) historically had the greatest number of students and offers specializations. Thus, the student population, the multiple tracks, and the complexity of the curriculum encouraged the researchers to pursue a graph theoretical analysis via CPN of the BS CE curriculum. By applying graph theory and centrality measures, the researchers aimed to gain valuable insights into the curriculum's structure. These findings helped identify critical courses and bottlenecks, and may serve as a basis to identify areas for improvement.

This preliminary study focuses exclusively on the structure of the engineering curriculum, analyzed through CPN methodology. It primarily examines how courses are interconnected through prerequisites, independent of individual students' performance; consequently, the study does not incorporate student grades or academic records. Specifically, the study aimed to construct a Course Prerequisite Network (CPN) for the BSCE curriculum of the academic year 2024-2025 and analyze the network to identify significant courses in the BSCE curriculum using degree centrality, betweenness centrality, and eigenvector centrality.

2. Content

2.1. Literature review

2.1.1. Conceptual framework

Course Prerequisite Network (CPN) analysis integrates graph theory and learning progression models, conceptualizing a curriculum as a directed acyclic graph (DAG) in which prerequisite links represent essential knowledge dependencies. This perspective aligns with constructivist theory, which posits learning as cumulative and scaffolded, with each course building upon the competencies developed in prior ones. In this framework, the curriculum functions as a system of interacting components where courses act as nodes and prerequisite relationships reflect the flow of information and the transfer of knowledge between courses. By examining these patterns of connectivity, CPN allows the curriculum to be explored as a structured knowledge network, revealing its depth, bottlenecks, coherence, and overall organization. Such theoretical grounding establishes CPN as an analytical approach that not only describes how a curriculum is arranged but also explains how its structure supports or constrains student learning.

In this study, the researchers analyzed the sequence of courses within the academic year (AY) 2024–2025 BSCE curriculum by depicting it as a course prerequisite network. The conceptual framework for this study is illustrated in Figure 1, emphasizing the research methodology. The diagram indicates that the starting point of the study was the examination of the curriculum, followed by the construction and utilization of a CPN to analyze how courses in the program were interlinked. Centrality measures, particularly degree centrality, betweenness centrality, and eigenvector centrality, were utilized in the analysis, yielding findings on pivotal courses and structural connectivity in the curriculum.

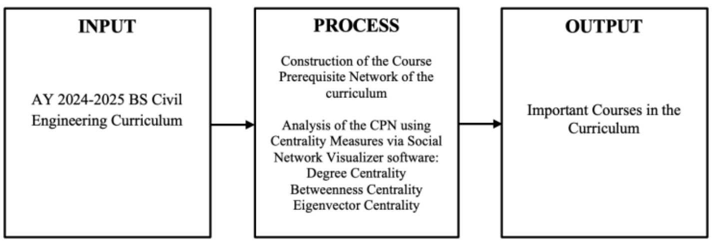

Figure 1. Conceptual framework of the study

2.1.2. Some graph theoretical background

Graph theory is a branch of mathematics that studies networks: their properties, functions, emerging patterns, and the interactions of their components. Its origins can be attributed to the Swiss mathematician, Leonhard Euler, who solved the Königsberg bridge problem in 1735 [12].

A network or graph is a visual representation of a system and is defined as a collection of points called nodes or vertices, connected by lines called arcs or edges. An edge connects exactly two vertices, and these serve as the endpoints of the edge. A vertex is considered incident to a specific edge if the vertex is an endpoint of that edge.

A graph can be either undirected or directed. An undirected graph is one where the vertices are connected by edges without regard to order. A directed graph is one where the edges are represented in the form of arrows to indicate a specific ordering, or direction. The tail of the edge is connected to the starting vertex, while the head is connected to the ending vertex. A vertex that is not incident to any edge is called an isolated vertex. In an undirected graph, the number of edges incident to a vertex is called its degree. In a directed graph, the in-degree of a vertex denotes the number of edges entering that vertex, while its out-degree denotes the number of edges exiting that vertex [13], [14].

Figure 2 illustrates examples of graphs where the vertices are labelled using lowercase letters. The undirected graph (left) comprises 7 vertices, with vertex *a* being isolated. The directed graph (right) consists of 10 vertices, where *c* is isolated. The in-degrees of the remaining vertices are as follows: *a* – 0, *b* – 0, *d* – 2, *e* – 1, *f* – 1, *g* – 1, *h* – 1, *i* – 1, and *j* – 1. The out-degrees are *a* – 1, *b* – 1, *d* – 1, *e* – 3, *f* – 0, *g* – 1, *h* – 1, *i* – 0, and *j* – 0.

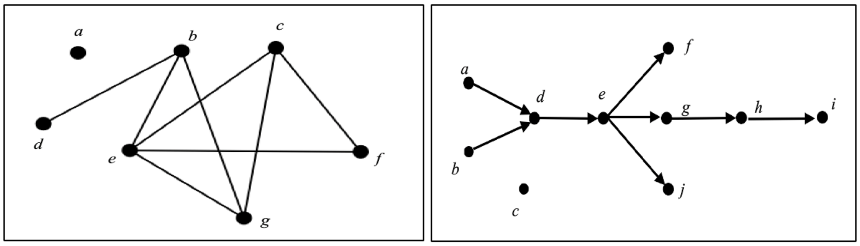

Figure 2. Example of undirected (left) and directed (right) graphs

2.1.3. Course prerequisite network and centrality measures

A Course-Prerequisite Network (CPN) is a directed graph that represents the flow of knowledge among various courses in an academic curriculum. CPNs can facilitate the visualization of complex curricula, providing critical observations and insights regarding the courses, thereby assisting students in navigation while enabling faculty and administrators to optimize their curricula. In a CPN, courses are denoted by vertices, and those with prerequisite relations are connected by directed edges (arrows), where the prerequisite is the source vertex pointing towards the target vertex or the course directly following it. In a curriculum, prerequisite courses are those that students must complete before enrolling in more advanced courses [6]. Assuming the directed graph in Figure 2 represents a CPN, the ten vertices *a* to *j* can be viewed as courses where *a* and *b* are considered prerequisites of *d*; *d* is a prerequisite of *e*; *e* is a prerequisite of courses *f, g*, and *j*; *g* is a prerequisite of *h*; and *h* is a prerequisite of *i*.

CPNs have attracted considerable interest from researchers as they allow for the discovery of underlying patterns and interactions within the structure of an academic curriculum. Slim et al. utilized CPNs to detect crucial courses that affect student progression in a program [15]. Aldrich discussed how the CPN framework can systemize curriculum mapping, identify gateway and isolated courses, and demonstrate structural hierarchies among courses [6]. Recent studies show that combining CPN analysis with student outcome data provides deeper insights into curriculum effectiveness. CPN structure was linked with completion and pass-rate data using probabilistic simulations to identify courses that delay graduation [16]. Another study integrated network metrics into an Outcome-Based Education system, demonstrating how central technical courses strongly influence student performance [17] while another found that certain prerequisite sequences create “high-risk pathways,” where student performance drops sharply [18]. In a more recent work, Slim et al. (2025) combined structural complexity with pass-rate data through their “Passability Complexity” metric, showing how bottleneck courses shape graduation outcomes [19]. CPNs across multiple institutions were compared, and results showed how foundational courses with high structural “reach” affect flexibility and progression [20]. Together, these studies highlight that CPN analysis, when enriched with educational outcomes, can identify structural risks, improve curriculum design, and support data-driven decision-making.

Centrality measures help identify the most significant courses in a curriculum by analyzing their position and influence within a CPN [13]. Although various centrality measures exist, this study focuses exclusively on three, namely: degree centrality, betweenness centrality, and eigenvector centrality.

Degree centrality quantifies the number of direct connections a course possesses. Degree centralities are categorized into in-degree, which denotes the number of prerequisites a course requires, and out-degree centrality, which refers to the number of courses for which it serves as a prerequisite. Courses with high out-degree measures are considered "gateway" subjects that unlock many others. Such courses typically tend to provide introductory concepts, and it is highly recommended that diagnostic assessments be conducted in these courses to determine students' baseline knowledge. On the other hand, courses with high in-degree often serve as capstones. It is further suggested that students taking such courses be exposed to higher-level learning activities that allow them to analyze, synthesize, and evaluate [5], [21].

In a network, betweenness centrality measures the frequency with which a certain vertex occurs within the shortest path connecting two other vertices, and a vertex with a high measure indicates that it has significant control over information flow [21]. In the context of a curriculum, this measure identifies how often a course acts as a bridge between others, making it useful for detecting bottleneck courses within the program, which may potentially cause delay in student progression if students struggle with them [20].

Eigenvector centrality emphasizes that the influence of vertices in a network is enhanced when they are connected to vertices of high importance. This measure is an extension of the degree centrality as it considers not only a course's direct links, but also the importance of the courses it connects, thereby highlighting strategically influential subjects [8], [13].

From the graph-theoretic approach by Lightfoot creating a conceptual model for analyzing the curriculum [5], to the visualization and structural analysis by Aldrich of academic programs [6], to the quantitative study by Slim et al. analyzing university-wide curricula and student flow [15], to the institutional implementation of curriculum network analysis by Simon de Blas et al. [8], and to the theoretical foundation and cross-disciplinary comparison of curricula by Stavrinides & Zuev [7], the use of CPN has evolved from small-scale theoretical applications to institutional-level analytics capable of guiding accreditation, redesign, and benchmarking. Indeed, CPN analysis has become an indispensable tool that can visualize knowledge flow, diagnose academic structure inefficiencies, provide data-informed support to academic planning, and enhance student progression and curriculum flexibility.

2.2. Methodology

2.2.1. Research design

A quantitative research design utilizing graph theoretical analysis was employed to examine the Bachelor of Science in Civil Engineering (BSCE) curriculum in this study. The curriculum, modelled as a directed graph, was explored to identify underlying relationships among courses. It was mathematically processed to generate graph metrics that provided quantitative insights into the importance of specific courses and revealed their level of influence on the curriculum, particularly regarding knowledge flow and program completion. The objective was to analyze the curriculum as a graph and apply centrality measures to identify pivotal courses and their respective roles within the academic structure.

2.2.2. Data gathering and analysis

The initial step involved constructing the directed graph serving as the Curriculum Prerequisite Network (CPN) of the BSCE curriculum using the network analysis software Social Network Visualizer (SocNetV). This software is designed for the visualization and analysis of social networks [21]. It is a practical tool for CPN analysis as it efficiently models directed prerequisite structures and automatically computes essential centrality measures. Furthermore, it provides clear visualizations enabling researchers to readily identify foundational courses, bottlenecks, and key conceptual hubs without requiring programming skills. Additionally, it is a free and open-source platform; consequently, its accessibility, combined with its rigorous analytic capabilities, makes it ideal for educational and curriculum research.

The subsequent step involved calculating various centrality measures via SocNetV to analyze the importance and connectivity of each course within the curriculum. Centrality measures serve as fundamental graph metrics in network analysis and are utilized in the study to identify the most pivotal courses within the BSCE curriculum. For this research, the selected centrality measures used were degree centrality, eigenvector centrality, and betweenness centrality. Newman discusses these measures in detail [13].

As the curriculum is represented by a graph, it has a corresponding adjacency matrix where the entries A_{uv} are given by

$$A_{uv} = \begin{cases} 1 & \text{if course } u \text{ is a prerequisite of } v \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

The in-degree centrality of course v, denoted by $C_{in}(v)$ counts how many courses u must be completed before v is taken. A high in-degree implies the course integrates knowledge from many prior subjects. It is given by the formula:

$$C_{in}(v) = \sum_u A_{uv} \quad (2)$$

The out-degree centrality of course v, denoted by $C_{out}(v)$ counts how many courses u have v as a prerequisite. A course with a high out-degree means it is foundational and unlocks many advanced subjects. It is given by the formula:

$$C_{out}(v) = \sum_u A_{vu} \quad (3)$$

The betweenness centrality is denoted by $C_B(v)$ shows how often a course lies on the shortest prerequisite pathways. A high betweenness value signals a bottleneck or bridge course essential for progression. The formula is given below, where s is a source course, while t is a more advanced target course. The values of σ_{st} and $\sigma_{st}(v)$ represent the number of shortest paths from course s to t and the number of shortest paths from s to t that pass through course v, respectively, where the fraction $\frac{\sigma_{st}(v)}{\sigma_{st}}$ is a measure of the importance of v in connecting s to t.

$$C_B(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}} \quad (4)$$

The eigenvector centrality score $C_E(v)$ indicates how influential a course is based on the importance of the courses connected to it. A high eigenvector score suggests that the course serves to anchor major conceptual areas of the program. The formula is given below, where λ is the principal eigenvalue of the adjacency matrix, while $\sum_u A_{vu} C_E(u)$ is the sum of the centrality scores of all important courses associated with v.

$$C_E(v) = \frac{1}{\lambda} \sum_u A_{vu} C_E(u) \quad (5)$$

2.3. Findings

2.3.1. Course prerequisite network construction

A Course Prerequisite Network (CPN) was developed to visually represent the interdependencies among courses in the AY 2024-2025 BSCE curriculum. This network serves as a critical tool for understanding the relationships between subjects, illustrating how specific courses serve as prerequisites or corequisites for others. The network is designed to highlight the curricular structure, ensuring that student progression through their academic journey is logical and coherent.

The 2024-2025 BSCE CPN consists of 94 nodes and 213 edges, where each node corresponds to a specific course within the curriculum, while the edges represent prerequisite and corequisite relationships among courses.

For enhanced visualization, a color-coded scheme was utilized in the CPN. General education courses, which provide foundational knowledge essential for engineering students, are represented in green. Technical courses, which emphasize application-based learning and engineering principles, are depicted in blue. Design courses, which focus on engineering design methodologies and problem-solving, are shown in orange. Specialized courses, which deepen students' understanding of core civil engineering topics, are assigned pink. Moreover, the edges connecting the nodes in the network are categorized based on their functional roles in course progression. Gray edges indicate prerequisite relationships, stipulating that a student must complete one course before enrolling in the next. This ensures that foundation concepts are mastered before moving on to more advanced ones. Conversely, black edges represent corequisite relationships, meaning the courses must be taken simultaneously. These corequisites facilitate the integration of related subjects, making learning more connected and effective. Figure 3 illustrates the CPN network constructed for the BSCE curriculum.

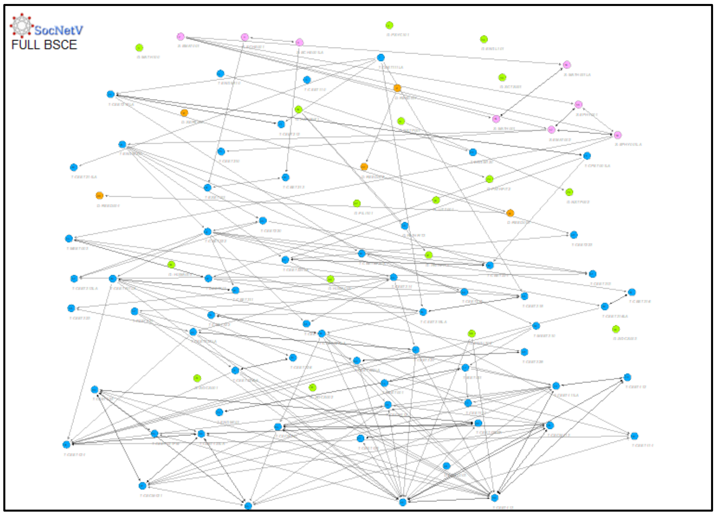

Figure 3. Course prerequisite network of the BSCE curriculum

2.3.2. Centrality measures of the BSCE Curriculum

**** Application of out-degree centrality***

Table 1 presents the top six courses in the Bachelor of Science in Civil Engineering (BSCE) curriculum based on out-degree centrality. Among the courses listed, T-CEET413LA (Node 81) exhibits the highest out-degree centrality with DC = 10.000000, normalized DC (dc') = 0.107527, and percentage DC (%DC') = 10.752688. Following this, T-CEET222 (Node 37) holds the second-highest out-degree with DC = 9.000000, dc' = 0.096774, and %dc' = 9.677419%.

Table 1. Top ten courses in terms of out-degree centrality

Node	Level	DC	dc’	%dc’
81	T-CEET413LA	10.000000	0.107527	10.752688
37	T-CEET222	9.000000	0.096774	9.677419
78	T-CEET411LA	8.000000	0.086022	8.602151
80	T-CEET413	8.000000	0.086022	8.602151
64	T-CEET322LA	7.000000	0.075269	7.526882
83	T-CECM411	7.000000	0.075269	7.526882

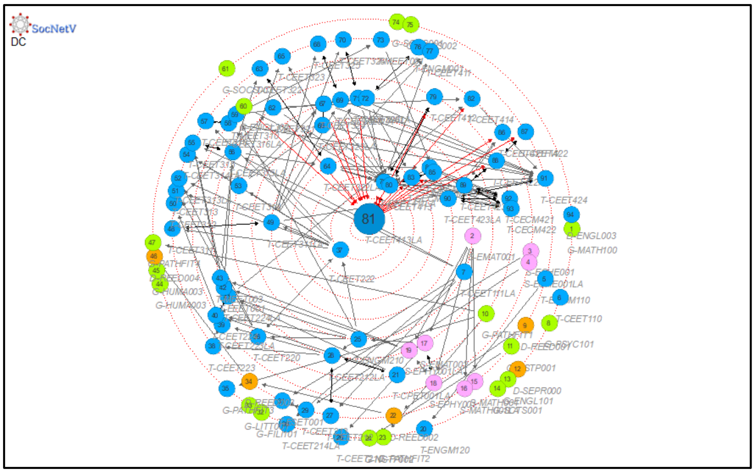

Figure 4. Course radial graph of the BSCE curriculum without-degree centrality emphasized

The analysis reveals that CE project 1 Laboratory (T-CEET413LA), taken in the first semester of the fourth year, exhibits the highest out-degree centrality. In the radial layout, Node 81, which represents this subject, is positioned at the center of the graph, signifying its pivotal role in the curriculum. The results show that CE project 1 laboratory has an out-degree of 10**,** meaning it functions as a prerequisite for 10 subsequent subjects.

The interpretation of Figure 4 indicates that T-CEET413LA is a critical course for establishing a strong foundation in civil engineering, ensuring that students acquire essential competencies before progressing to more specialized topics. Furthermore, the out-degree centrality provides additional insight into the role of T-CEET413LA in the curriculum. Out-degree centrality measures the number of direct connections from a course to its subsequent dependent courses, highlighting its influence on academic progression. A high out-degree value for T-CEET413LA indicates that this course acts as a gateway for multiple advanced subjects.

**** Application of in-degree centrality***

Table 2 presents the top courses in the BSCE curriculum based on in-degree centrality. Among the listed courses, T-CEET413LA (Node 81) exhibits the highest in-degree centrality with DCin = 14.000000, normalized in-degree DC (dc') = 0.150538, and percentage in-degree DCin (%dcin') = 15.053763. Following this, T-CEET413 (Node 80) ranks second with DCin = 13.000000, dcin' = 0.139785, and %dcin' = 13.978495, indicating that it also possesses a strong dependency on prior subjects.

Table 2. Top ten courses in terms of in-degree centrality

Node	Level	DCin	dcin’	%dcin’	Level
81	T-CEET413LA	14.000000	0.150538	15.053763	T-CEET413LA
80	T-CEET413	13.000000	0.139785	13.978495	T-CEET413
91	T-CEET424	9.000000	0.096774	9.677419	T-CEET424
93	T-CECM422	7.000000	0.075269	7.526882	T-CECM422
92	T-CECM421	7.000000	0.075269	7.526882	T-CECM421
90	T-CEET423LA	7.000000	0.075269	7.526882	T-CEET423LA
83	T-CECM411	7.000000	0.075269	7.526882	T-CECM411
78	T-CEET411LA	7.000000	0.075269	7.526882	T-CEET411LA

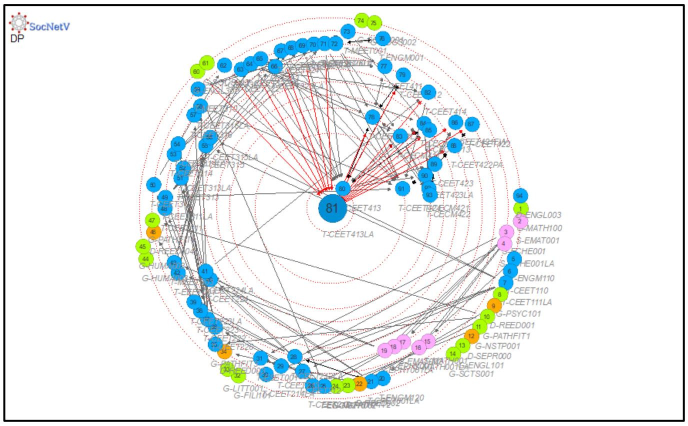

Figure 5. Course radial graph of the BSCE curriculum with in-degree centrality emphasized

The analysis demonstrates that CE project 1 laboratory (T-CEET413LA) and CE project 1 (T-CEET413), taken in the first semester of the fourth year, exhibit the highest in-degree centrality. In the radial layout, Node 81 (CE project 1 laboratory) has an in-degree of 14, while Node 80 (CE project 1 lecture) has an in-degree of 13. In Figure 5, the in-degree centrality metric was calculated for all nodes in the BSCE CPN. These two courses emerged as the most dependent nodes requiring 14 and 13 prerequisite courses, respectively.

Both T-CEET413 and T-CEET413LA are advanced courses that integrate knowledge from multiple prior subjects. CE project 1 lecture (T-CEET413) focuses on the theoretical concepts and design principles behind civil engineering projects, enabling students develop analytical and planning skills. Meanwhile, CE project 1 laboratory (T-CEET413LA) provides a practical application where students implement these concepts by building models, conducting experiments, and working on real-world engineering projects.

The high in-degree of these courses confirms that they are pivotal capstone subjects where students engage in higher-order thinking skills, such as analyzing, synthesizing, and evaluating, as defined in Bloom's taxonomy. Their central role in the curriculum ensures that students acquire a comprehensive knowledge base before tackling complex engineering challenges. This metric facilitates more effective assessments, ensuring that they accurately measure student learning and contribute to continuous curriculum improvement.

Application of betweenness centrality

Table 3 presents the top courses in the BSCE curriculum based on betweenness centrality. Among the listed courses, T-CEET413LA (Node 81) exhibits the highest betweenness centrality with BC = 301.883905, normalized BC (BC') = 0.035283, and percentage BC (%BC') = 3.528330. Following this, T-ENGM210 (Node 25) ranks second with BC = 139.715873, bc' = 0.016330, and %bc' = 1.632958, while T-CEET413 (Node 80) has a similar role with BC = 139.116219, bc' = 0.016259, and %bc' = 1.625949%.

Table 3. Top ten courses in terms of betweenness centrality

Node	Level	BC	bc'	%bc'
81	T-CEET413LA	301.883905	0.035283	3.528330
25	T-ENGM210	139.715873	0.016330	1.632958
80	T-CEET413	139.116219	0.016259	1.625949
64	T-CEET322LA	137.617460	0.016084	1.608432
56	T-CEET315LA	119.617460	0.013981	1.398054

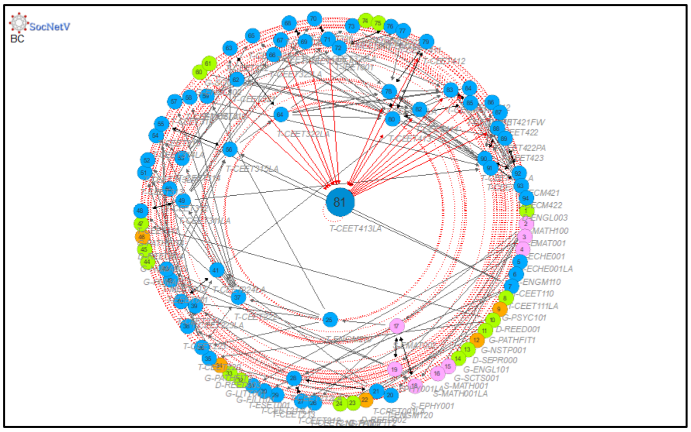

Figure 6. Course radial graph of the BSCE curriculum with betweenness centrality emphasized

The analysis demonstrates that CE project 1 laboratory (T-CEET413LA), taken in the first semester of the fourth year, possesses the highest betweenness centrality. In the radial layout, Node 81 (CE project 1 laboratory) has an in-degree of 14 and an out-degree of 10. This means that this subject serves as a pivotal nexus between multiple prerequisite and succeeding courses, making it an integral component of the curriculum structure.

As illustrated in Figure 6, the peak betweenness centrality of T-CEET413LA signifies its roles as a critical bridge between foundational and advanced coursework. This suggests that a significant number of academic pathways converge at this node, connecting disparate segments of the curriculum. Consequently, T-CEET413LA plays a fundamental role in solidifying core engineering concepts before students transition to more specialized domains.

A comparison of Figures 4, 5, and 6 reveals that T-CEET413LA is consistently identified by multiple centrality measures as a critical node within the program. This metric reinforcement underscores the robustness of the graph-theoretic approach in curriculum analysis, providing a systematic method for evaluating course importance and optimizing curriculum alignment. When combined with domain-specific expertise, this approach offers a powerful tool for curriculum design, ensuring that key courses like T-CEET413LA effectively support student learning and academic progression.

**** Application of eigenvector centrality***

Table 4 presents the top courses in the BSCE curriculum based on eigenvector centrality (EVC). Among the listed courses, T-CEET413LA (Node 81) exhibits the highest eigenvector centrality with EVC = 0.366913, normalized EVC (evc') = 1.000000, and percentage EVC (%evc') = 100.000000. Following this, T-CEET322LA (Node 64) ranks second with EVC = 0.355039, evc' = 0.967636, and %evc' = 96.763636%. Similarly, T-CEET413 (Node 80) demonstrates a similar influence with EVC = 0.353829, evc' = 0.964341, and %evc' = 96.434064%.

Table 4. Top ten courses in terms of eigenvector centrality

Node	Level	EVC	evc’	evc’’	%evc’
81	T-CEET413LA	0.366913	1.000000	0.079609	100.000000
64	T-CEET322LA	0.355039	0.967636	0.077032	96.763636
80	T-CEET413	0.353829	0.964341	0.076770	96.434064
83	T-CECM411	0.318503	0.868060	0.069105	86.805964
85	T-CECM413	0.272116	0.741635	0.059041	74.163541
84	T-CECM412	0.272116	0.741635	0.059041	74.163541

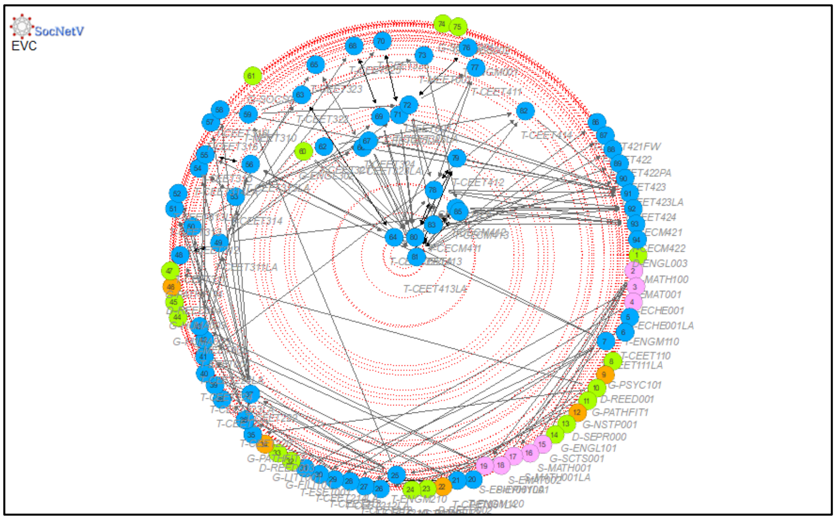

Figure 7. Course radial graph of the BSCE curriculum with eigenvector centrality emphasized

The analysis reveals that CE project 1 laboratory (T-CEET413LA), CE project 1 (T-CEET413), and Quantity surveying laboratory (T-CEET322LA) possess the highest eigenvector centrality. In the radial layout, Nodes 81, 80, and 64 are positioned at the core of the graph, signifying their dominant influence within the curriculum.

As illustrated in Figure 7, these courses emerge with the highest eigenvector centrality values in the BSCE program. This indicates that these courses are not only critically important on their own but are also strategically linked to other influential subjects, acting as catalysts for students through their academic progression. Since these courses serve as central hubs in the curriculum, they should be deliberately structured to reinforce the competencies evaluated in capstone projects. Their robust connections with other subjects demonstrate their ability to synthesize knowledge from multiple engineering disciplines, enabling students to establish a comprehensive foundation before engaging with advanced coursework.

A second implication that can be drawn from this graph-theoretic analysis is that courses with moderate but still significant scores should introduce fundamental concepts that are subsequently reinforced in more advanced subjects. These courses can also serve as strategic early assessment points to evaluate students' conceptual mastery and readiness for the rigorous demands of the program.

The consistent identification of T-CEET413LA, T-CEET413, and T-CEET322LA across multiple centrality measures highlights their paramount role within the academic structure. This triangulation of metrics reinforces the usefulness of a graph-theoretic approach in quantifying course influence and optimizing the strategic placement of assessments. Such an approach is essential for enhancing student learning outcomes and ensuring the coherence of the overall curriculum.

3. Conclusions

The analysis demonstrates that the BSCE curriculum is characterized by a complex web of independent courses. The Course Prerequisite Network (CPN) developed for the 2024-2025 BSCE curriculum effectively visualizes these interconnections, facilitating the identification of pivotal subjects and a deeper understanding of its programmatic architecture. Through the application of centrality measures, the study quantified the relative significance of the specific courses within the network. Notably, CE project 1 laboratory (T-CEET413LA) and CE project 1

(T-CEET413) exhibited a high degree of centrality, indicating their extensive connectivity within the curriculum. Furthermore, these subjects displayed high betweenness centrality, signifying their role as essential bridges that facilitate the seamless transition from foundational concepts to specialized engineering topics.

The eigenvector centrality analysis further confirmed that these courses are integrated within a cluster of high-influence subjects, reinforcing their status as structural anchors. Collectively, these findings validate that the CE project 1 series is paramount to the BSCE curriculum. These courses function as integrative hubs, ensuring students are adequately prepared to synthesize knowledge when confronting advanced and complex engineering challenges.

This study serves as a preliminary phase to a more comprehensive, student performance- and outcomes-focused curriculum investigation. It utilized Curriculum Prerequisite Network analysis to examine the structural organization of an undergraduate Civil Engineering curriculum. The analysis highlights course interdependencies and critical pathways, offering a systemic perspective on curriculum design and progression.

In the context of the Philippine K–12 reform, such structural evaluations are imperative, given the increasing diversity in students' academic preparation as they transition to higher education. While student performance and learning outcomes were beyond the scope of this study, the findings provide a foundational structural framework. This assessment can inform future outcome-based and performance-oriented research that educators and academic program designers can pursue.

Future research studies should integrate CPN analysis with empirical performance data to achieve a holistic evaluation of curriculum effectiveness. Potential avenues for investigation include:

- Qualitative assessment: Conducting exit interviews to determine students' perception of how the curriculum structure influenced their academic performance upon completing key courses.
- Long-term tracer studies: Exploring graduates' career performance to evaluate the long-term efficacy of a curriculum designed through prerequisite analysis.
- Comparative Analysis: Applying CPN analysis to other academic programs or institutions to identify universal patterns in course structures and establish benchmarks for optimal program design.
- Data-driven validation: Incorporating student performance metrics to empirically validate the extent to which strategic course planning and prerequisite alignment support learning outcomes.

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