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Research Article

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Curriculum mapping: Unveiling the connections among courses and program learning outcomes

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Abstract

The curriculum should be a living organism, constantly evolving as society, technology and education change. Long-term curriculum renovation is required to sustain coherence among learner outcomes, teaching, learning and assessment in teacher preparation programs. This process aids discovering gaps and keeping curricula up to date with new educational trends to prepare future teachers for their work. The interest in curriculum development is increasing; however, methods are still emerging particularly in teacher education where connections between the content of the course contents and program learning outcomes are often not established. Blending expertise with scholarship is important for enriching the academic

experiences of student teachers. This study is specific to a course from a biology curriculum for students studying to become biology teachers, but has broader applicability. It focuses on the extent to which PLOs are embedded within the curriculum, and it also identifies some deficiencies about professional competences that are needed from prospective biology teachers. The study is structured into sub-sections that focus on current curricular design, analysis of PLOs and survey of their distribution in the programme of biology teacher education in Albania. The study also works towards enhancing some of the curriculum planning practices in teacher education.

Keywords: Program Curriculum Mapping, Curriculum Development, Learning Outcomes.

1. Introduction

Curriculum development is a continuous, iterative process that requires ongoing reflection and planning to shape educational activities over time. As societal, technological, and pedagogical landscapes evolve, so too must the curriculum (Ornstein & Hunkins, 2009). The rapid pace of change in knowledge and teaching methods presents both challenges and opportunities, making it vital for teacher education programs to continuously adapt. To ensure that teachers are prepared to meet the demands of modern classrooms, curricula must be regularly redesigned to reflect new teaching strategies, educational research, and the needs of diverse learners (Fraser, 2006). As part of curriculum review, curriculum mapping plays a crucial role in this process, offering a structured approach to align learning outcomes, instructional activities, and assessments. By doing so, it ensures that teacher formation programs are consistently responsive to emerging educational trends, providing future educators with the necessary tools, knowledge, and competencies to excel in their teaching practice (Sunitha, Jangaraj, Raju, & Madhavi, 2021). Curriculum mapping appears to be a valuable toolkit as it helps identify gaps that can be addressed to revise and update programs (Auras, et al., 2022). Numerous initiatives have been undertaken in curriculum mapping; however, despite the increasing attention and interest in this area, the methodology for curriculum mapping is still evolving (Urbana II, 2018).

In teacher education curricula, there is a notable lack of focus on examining the connection between the content and program learning outcomes (Lam & Tsui, 2013). This gap highlights the potential value of curriculum mapping as a tool for addressing this issue. Recent literature underscores the importance of integrating professional knowledge (teaching competencies) with academic studies (subject-specific knowledge) in teacher education programs to enhance student teachers' learning experiences (Huber & Hutchings, 2004; Lam & Tsui, 2013). Curriculum mapping could offer a structured approach to bridge this gap, ensuring a more coherent and comprehensive teacher education curriculum. Although the focus of this article is the biology curriculum for teachers, the methodology can also be used for other programs. The Program Learning Outcomes (PLOs) form the foundation for developing the professional competencies of biology teachers, deemed by curriculum developers as both essential and beneficial (Dyjur, P., 2019). However, a critical examination is

necessary to assess how these outcomes are integrated, not only within individual courses but across the entire program. This approach aims to reveal the extent to which the course knowledge and skills required for meeting professional standards in teaching biology are explicitly addressed throughout the teacher's educational curriculum. By scrutinizing this alignment, we can challenge assumptions about curriculum effectiveness and identify potential gaps or inconsistencies in how these professional competencies are nurtured.

This study is organized into distinct sections, each designed to explore key aspects of curriculum mapping and its application in educational settings. The first section examines the current trends, challenges, and opportunities within curriculum mapping, while also laying out the rationale behind this research. The following section shifts focus to analysis of Program Learning Outcomes (PLOs) and the methodologies employed in the curricula mapping process. The study unveils findings regarding the distribution of PLOs across the sample degree, offering a comparative analysis based on the curriculum structures and academic timelines of the biology teacher education program in Albania. The final section explores the broader implications of these findings, highlighting their potential to inform and enhance curriculum planning practices in teacher education programs (Lam & Tsui, 2013). This study explores the application of curriculum mapping to examine how well the PLOs, defined for "curriculum and instruction" within biology teacher education degree, are represented in the planned curriculum (course syllabi). It also investigates the distribution of these outcomes across the organization of courses in biology teacher program. The primary goal of this research is to provide a comprehensive framework for curriculum mapping, offering valuable insights into how teacher education programs can be better planned, to support both the qualification and ongoing professional development of educators.

2. Literature and Research Review

Curriculum mapping is an analytical process through which the content, learning outcomes, and instructional strategies across courses are examined and organized. This process facilitates a comprehensive understanding of the curriculum's coherence and alignment, offering critical insights into the ways in which students engage with and progress through their academic discipline (Jansen, 2004). Additionally, curriculum mapping enhances awareness of the content covered across courses (Balanger & Oakleaf, 2013). Curriculum mapping also serves as a strategic tool to accomplish a range of objectives, including program planning, evaluation, and the coordination of academic activities inside the program. From an administrative perspective, curriculum mapping provides valuable data that can be utilized to assess program learning outcomes and track their progression and evaluate course efficacy. Additionally, curriculum mapping facilitates the systematic organization of instructional materials, supports the development of lector guides, and enhances the diversification of learning levels within a program, course, or activity (Johnson,

Carlile, Checkley, & Baker, 2006). Moreover, curriculum mapping empowers programs to methodically quantify their activities, visually assess their strengths and areas for improvement, and present the key highlights and outcomes of their practices in a clear and impactful manner to students and all stakeholders (Schutte, Line, & McCullick, 2018). It is also important that curriculum mapping and assessment are often touted as essential tools for monitoring student learning progress and ensuring that students acquire the knowledge and skills necessary for success in their future careers. However, a critical examination reveals that these methods may fall short in capturing the complexity of student development. While they provide structured frameworks for aligning course content with program learning outcomes, they may not fully account for the dynamic and diverse nature of learning. Furthermore, the focus on predefined knowledge and skills can potentially overlook the broader competencies, such as critical thinking, creativity, and adaptability, which are increasingly vital in today's rapidly evolving job market. Therefore, while curriculum mapping and assessment can offer valuable insights, they should not be seen as the sole indicators of a student's preparedness for their career path (Okojie, Bastas, & Miralay, 2022).

Program curriculum mapping is a strategic and evidence-based methodology aimed at aligning instructional practices with established program goals and learning outcomes. It provides a comprehensive overview of the content being taught, the sequencing of instruction, and how each element contributes to achieving the program's educational objectives (International Best Practice. Program Curriculum Design, 2015). Key features of curriculum mapping include the documentation of content, which maps what is taught and when, offering a clear representation of the curriculum. It also aids in the identification of gaps by revealing areas where content may be missing or insufficiently covered. Additionally, curriculum mapping supports assessment planning, enabling the design of a comprehensive evaluation framework to measure student progress relative to learning (Okojie, Bastas, & Miralay, 2022). In this light, the benefits of curriculum mapping are multifaceted: it fosters improved communication among faculty regarding the structure and content of the curriculum, enhances program coherence by ensuring consistency and logical alignment across courses, and increases student success by promoting alignment with the program's learning outcomes. Moreover, curriculum mapping encourages reflective practice, allowing for ongoing evaluation and enhancement of teaching methods and course content. More advanced curriculum maps further extend their utility by incorporating teaching methodologies and assessment strategies, thereby tracking students' progress throughout the program (McKenney, Nieveen, & Van Den Akker, 2006) (Saad, 2014). Curriculum mapping serves also as an effective tool for assessing the alignment of courses within an academic department with its established PLOs, and its methodologies can be applied across various educational settings. And the most important is that curriculum mapping provides critical insights that can inform and improve the curriculum planning process within teacher education programs (Lam & Tsui, 2013). Curriculum mapping is effective

in recognizing both the vertical alignment of program learning outcomes within a course and their horizontal alignment across the entire program (Uchiyama & Radin, 2009). In certain respects, curriculum mapping can provide insights into the coverage and distribution of specific PLOs across a program, aiding teachers in understanding the connections between PLOs and planning a more integrated curriculum. While this approach offers potential benefits for curriculum development, it assumes that the distribution and connections of PLOs are always clear and straightforward. A critical perspective would question whether mapping alone can truly capture the complexity of curriculum design, considering the diversity of student learning needs and the potential limitations of a one-size-fits-all approach to curriculum integration (Lam & Tsui, 2013)

The literature also addresses the prerequisites for effective curriculum mapping, emphasizing that a successful mapping process hinges on the establishment of a trusted environment. This is crucial for exposing participants' pre-reflective assumptions and biases, allowing them to be critically examined and confronted, ultimately fostering a collaborative space where a shared, thoughtful understanding can emerge (Hogan, 2017). Aligning curriculum goals with taught content and student learning enhances the efficiency of curriculum design and implementation, while deepening the significance of the educational process (Lam & Tsui, 2013).

Constructive alignment, as outlined by Biggs (2014), is a teaching design framework that ensures coherence between what students are expected to learn, how they demonstrate their learning, and how academic activities and assessments are structured (Biggs, 2022). This approach emphasizes the importance of clearly defined learning outcomes before teaching begins, so that teaching strategies are intentionally designed to engage students in activities that enhance their ability to achieve these outcomes. In this framework, assessments are not merely tools for grading but are carefully crafted to measure how well students have attained the desired outcomes. Biggs (2014) also asserts that learning is not simply transmitted from teacher to student; rather, it is constructed through the student's own active engagement and behavior, aligning with Tyler's (1949) view that it is the learner's actions that lead to learning, not the teacher's direct input (Biggs, 2022). Constructive alignment recognizes that when learning activities are purposefully designed to help students develop the required knowledge and skills, and when these activities are closely linked to assessments, the likelihood of achieving the intended learning outcomes increases. The approach emphasizes the critical role of assessment, arguing that assessment drives student learning and, when aligned with learning goals, optimizes the learning experience. The University's framework for unit design encapsulates this process, guiding educators to first identify learning outcomes, design assessments that measure these outcomes, plan activities that foster the desired knowledge and skills, and select content that supports these activities. However, a critical perspective suggests that while this approach provides structure, it may overlook the complexity of student learning, as it assumes all students will respond similarly to the same teaching strategies and assessments, potentially disregarding individual learning

needs and diverse educational contexts (Biggs, 2022). Although curriculum mapping is frequently employed, its findings are often underreported. To be effective, curriculum mapping should be purpose-driven, with a clear objective that informs the choice of standards, metrics, and the interpretation of the resulting data (Smith & Chittams, 2024)

For the purposes of this study, a learning outcome refers to the intended effect of an educational program, defined by specific, observable, and measurable student performance (Veltri, Webb, Matveev, & Zapatero, 2011). It outlines the knowledge, skills, and attitudes students are expected to achieve by the end of a unit of study. The term "learning outcome" is broad and can be applied at various levels, including lesson, course, program, or institutional levels, with institutional outcomes often referred to as graduate attributes (Veltri, Webb, Matveev, & Zapatero, 2011).

Dyjur, P., Grant, K., & Kalu, F. (2019) provide an example that demonstrates how learning outcomes can be expressed at different levels. At the graduate attribute level, communication is emphasized. At the program level, the learning outcome focuses on students being expected to write an evidence-based research paper, drawing up relevant literature in the field. At the course level, the outcome is more specific, requiring students to evaluate the literature and select appropriate sources to support their arguments. Finally, at the lesson level, the objective is even more focused, with students being expected to use a standard citation style in their written work. This example illustrates the varying scope and specificity of learning outcomes, from broader attributes to specific, measurable goals at the lesson level (Dyjur, Grant, & Kalu, 2019). Likewise, PLOs play a crucial role in defining the core objectives and unique aspects of a program, as they explicitly communicate what is prioritized and valued within the curriculum. However, it is essential to critically examine whether PLOs truly reflect the program's broader goals or merely serve as a superficial outline. While PLOs aim to guide both students' learning experiences and program decision-making, their effectiveness depends on how well they align with actual teaching practices and assessment methods. Additionally, PLOs must be carefully articulated not only to students but also to broader stakeholders, ensuring that they genuinely represent the program's educational intentions rather than just fulfilling formal requirements. This is where curriculum mapping becomes invaluable (Veltri, Webb, Matveev, & Zapatero, 2011). By visually representing how PLOs are integrated into the curriculum, mapping provides a systematic way to ensure that these outcomes are consistently addressed across courses and that the learning experiences align with the intended goals. Curriculum mapping helps identify gaps, redundancies, or misalignments, offering a transparent method for improving program coherence and ensuring that PLOs are truly reflected in students' learning journeys (Lam & Tsui, 2013; Dyjur, Grant, & Kalu, 2019).

When developing PLOs for teacher education, one effective strategy is to examine the competencies or guidelines provided by professional organizations and regulatory bodies that oversee the teaching profession. These organizations often establish standards that define the core competencies required for effective teaching. However,

it is equally important to incorporate insights from potential employers in the education sector. Engaging with these stakeholders can offer valuable perspectives on the specific competencies they expect from future educators. This collaborative approach not only ensures that PLOs reflect current professional standards but also helps align the teacher education program with the practical needs of the workforce. By critically integrating both established professional frameworks and employer expectations, PLOs can be crafted to more effectively prepare graduates for the realities of teaching, while also allowing for ongoing adaptation as the profession evolves (Dyjur, Grant, & Kalu, 2019). Additionally, PLO presents a unique opportunity for faculty to engage in a collective reflection on the overarching purpose of the program. While there may be broad agreement on the program's goals, this process often uncovers subtle differences in perspectives among staff members. By involving all instructors in crafting or revising the PLOs, a dynamic conversation unfolds, fostering deeper insights into the program's objectives. This collaborative approach not only enhances understanding of the program's purpose but also encourages instructors to shift their focus from individual course content to the collective impact of the entire program. In doing so, faculty members can align their efforts more effectively, ensuring a cohesive and unified approach to program learning outcomes.

Further research is necessary to explore how programs design and integrate PLOs throughout their curricula. It is essential to investigate not only the alignment of PLOs with course-level outcomes and instructional activities but also the broader impact these outcomes have on teaching and learning dynamics. Curriculum mapping can play a key role in this process by providing a systematic approach to ensuring that PLOs are consistently and effectively integrated across courses. Additionally, there is a need to examine how faculty and students perceive PLOs and how these perceptions influence their engagement with the curriculum. Without such examination, we risk overlooking potential misalignments and missed opportunities for improving the educational experience and ensuring that PLOs effectively guide both teaching strategies and student achievement (Clark & Hsu, 2023)

Although curriculum mapping at the program level is a widely adopted practice, it frequently fails to capture the full complexity of educational alignment, as it tends to emphasize course-level associations with learning outcomes at the expense of deeper pedagogical and developmental considerations. This approach can sometimes obscure critical nuances in teaching and learning, such as the depth of student engagement or the evolving nature of pedagogical practices. Therefore, while curriculum mapping offers valuable insight into the alignment of courses with intended outcomes, it must be critically examined to ensure that it captures a comprehensive view of the learning process across the program and is not merely a superficial exercise in documentation (Urbana II, 2018) By the same token, mapping provides a visual representation of how various components align with program learning outcomes, offering a framework to examine and refine educational design. However, it is merely a tool, and its effectiveness depends on how we use it to understand where and how students are learning. To gain a deeper insight, it is crucial to overlay the student experience

onto the map, examining factors like course-taking patterns and participating in co-curricular activities. If students are not progressing through the curriculum as intended or if only certain groups are engaged, the expected learning outcomes may not be achieved. Thus, while curriculum mapping can inform our design, it must be paired with a critical consideration of student access, equity, and participation to ensure that learning pathways are both realistic and inclusive (Urbana II, 2018).

3. Method of Study and data

Mapping program learning outcomes aligns with the main objective of our study, aiming to critically examine how the content of the biology teacher master program constructs the necessary framework of skills and knowledge to meet professional standards. To respond to that question, a rigorous multi-step process was used with the utmost commitment to transparency and fairness at every stage. The analysis, in terms of both quantitative and qualitative nature, was based on main data sources that comprised of:

1. The courses in the study program under consideration.
2. A list of the Program Learning Outcomes (PLOs) for the entire program and for each course.
3. The assessment of the contribution of individual courses towards the attainment of the program-level PLOs. The first two steps were focused on a review of all relevant curriculum documents including the national curriculum, course syllabi, and the diploma supplement for the advanced level of the Master´s program of Biology Teacher Education. Third, guideline three took into consideration information obtained during personal assessment and through interviews with teacher participants in the project.

This facilitated the opportunity to see the extent to which PLOs are addressed at the program and course level […] However, while such a process bears potential fruit, there is also an issue regarding how well the final documentation product reflects the interface between intended outcomes and what the curriculum does 'on the ground' and whether the whole way students learn is actually captured (Lam & Tsui, 2013; Smith & Chittams, 2024). In addition to examining the coverage of PLOs, curriculum mapping was also used to map the distribution of PLOs. The implications of this distribution are explained in terms of course-level learning outcomes and program planning by describing how PLOs are addressed in the context of an individual course (vertical extent) and how PLOs are distributed across the program (horizontal extent). Such an analysis helped determine how the program achieves coherence and consistency in covering the expected outcomes across the curriculum (Adsit, Ellis, & Ford, 2014). The approach to this study required identifying the Program Learning Outcomes (PLOs) at the curriculum level for the Biology Teacher Education program and how they relate to the program content. These PLOs constitute a foundation upon which to build the professional competencies needed for

future biology teachers that are not only necessary but also important. The methodology employed in this study necessitated the identification of Program Learning Outcomes (PLOs) at the curriculum level for the Biology Teacher Education program and their alignment with program content. These PLOs form the foundation for cultivating the professional competencies required of future biology teachers and were considered by curriculum developers to be both essential and of high value. Within this framework, the study further investigates the extent to which these outcomes are operationalized within individual courses and integrated across the entire program. This analysis aims to determine how explicitly the curriculum addresses the knowledge, skills, and dispositions necessary for meeting the professional standards expected of biology teachers in higher education settings.

Table 1. List of Program Learning Outcomes: Master of Science for Biology Teachers

Program Learning Outcomes (PLO-s)	Code
Knowledge and Implementation of Educational Documents	PLO-1
Scientific Preparation	PLO-2
Curriculum and Key Competency Development	PLO-3
Teaching, Learning, and Inclusion	PLO-4
Assessment of Learning	PLO-5
Professional and Personal Development	PLO-6
Collaboration with Colleagues and Communication	PLO-7
Collaboration with the Community	PLO-8

Results and discussion

We conducted a content analysis of the Master of Science in Education program offered by the Faculty of Natural Sciences at Tirana University. Table 2 presents the 20 courses analyzed in this study (from each 3 elective courses with 2 possibilities of choice for more info see Table 3), which are part of the program's first and second years. The diploma was analyzed separately from the other courses, because it does not have an equal impact on PLO-s, nor does it follow the same approach as the other courses included in the main analysis. The Master of Science program for Biology teachers is a two-year, 120 ECTS full-degree program, designed to prepare qualified biology teachers for high school education. This program is open to students who have completed the first cycle of higher education in Biology, specifically a bachelor's degree in biology (3 years, 180 ECTS). The goal of this master's program is to provide university graduates with a pathway to become qualified biology teachers. Upon

completion of the program, graduates must undertake a three-month internship at a school and successfully pass a state licensing exam to earn their teaching certification.

Table 2. Curriculum Mapping for master's degree for Biology teacher

Course Code	Courses	Credits	Program Learning Outcomes									%
			PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	Total	
C 1	Developmental Psychology	4	0	2	1	0	0	1	2	0	6	2.81
C 2	Student Assessment	5	1	1	2	1	3	2	0	0	10	4.69
C 3	Teaching Methodology and Critical Thinking	7	1	2	2	2	1	2	1	0	11	5.16
C 4	Curriculum Development	4	2	2	3	2	1	2	0	0	12	5.63
C 5	Learning and Classroom Management	6	1	1	2	3	1	1	2	2	13	6.1
C 6	Educational Psychology	4	0	2	1	0	0	1	2	1	7	3.28
C 7	Supplementary in Biology	5	1	3	1	2	2	2	0	1	12	5.63
C 8	Methodology of Teaching Biology	6	1	2	3	2	1	2	2	0	13	6.1
C 9	Biology Curriculum in Pre-University Education	7	2	2	3	2	1	2	0	0	12	5.63
C 10	History of Biological Thought	3	1	3	1	0	0	2	0	1	8	3.75
C 11	Foreign Language in Biology Teaching	3	0	0	2	0	0	2	1	0	5	2.37
C 12	Elective Subject I/1	3	0	2	2	2	1	1	0	1	9	4.22
C 13	School Practice I	3	2	2	2	1	1	1	1	1	11	5.16
C 14	Practical Skills and Projects in Biology	7	1	2	3	2	2	1	1	0	12	5.63
C 15	Critical Thinking and Testing in Biological Education	6	1	1	2	2	3	2	0	0	11	5.16
C 16	Human Anatomy	3	0	2	1	1	0	0	0	0	4	1.87
C 17	Practicum: Teacher's File Preparation in School	2	3	1	2	0	2	0	0	0	8	3.75

C 18	**Elective Subject II/2**	3	0	3	1	1	0	0	0	0	5	**2.37**
C 19	**Elective Subject II/3**	3	0	2	1	1	0	2	0	0	6	**2.81**
C 20	**School Practice II**	6	2	2	2	2	2	2	1	1	14	**6.57**
C 21	**Diploma**	30	0	3	3	2	3	3	0	0	14	**6.57**
	Total	**120**	**20**	**40**	**40**	**28**	**24**	**31**	**13**	**8**	**213**	
	%		**9.38**	**18.77**	**18.77**	**13.14**	**11.26**	**14.55**	**6.1**	**3.75**		

Table 3. Elective Subject code per each Elective course and credits

Elective Subject code	Elective Courses	Credits
I/1	Environmental education	3
I/1	Health Education	3
II/2	Ethology	3
II/2	Bioethics	3
II/3	Aquatic Biomet	3
II/3	The Use of IT in Teaching	3

Each of the 5 members of the evaluation team (5 professors that teach on this program and know in deeply all the subjects) independently assessed the extent to which the 8 general course learning outcomes were addressed in the course documents for each subject, using a predefined coding system. This coding system assigned numerical values as follows:
0 = Not applicable
1 = Introduced (I)
2 = Developed (D)
3 = Mastered (M)
Using these levels, members of the evaluation team mapped each program learning outcome to the corresponding course documentation. To ensure consistency and enhance inter-rater reliability, the team employed a shared set of rating criteria throughout the mapping process. After completing their evaluations independently, the team convened to compare and discuss their ratings. Adjustments to individual ratings were permitted if a consensus was reached during the review meeting. In cases where consensus could not be achieved, the ratings for a given course area were only considered valid if at least three evaluators provided the same score.
The Curriculum Mapping analysis reveals that different courses of the master's degree

for Biology teacher contribute in varying degrees to the achievement of each PLOs. The Figure 1 graphically illustrates both the frequency of course contributions to each PLO and the quality of those contributions. A closer analysis of this distribution highlights several notable gaps. Notably, PLOs 7, and 8, lack any course that supports their mastery level—a significant concern when evaluating curriculum coherence and alignment.

The data for PLO 2 shows a marked dispersion in course contributions: only 4 courses introduce the outcome (I=1), while 12 courses develop it (D=12). This imbalance raises questions about whether students receive adequate foundational exposure before being expected to build advanced competencies. A similar pattern is observed in PLO 4 and PLO 6, though the gap occurs between development (D) and mastery (M). For PLO 4, nine courses are involved in developing the outcome, but only one course supports its Mastery—a limited pathway for students to achieve higher-order learning. The situation is mirrored in PLO 6, with 11 courses development-level contributions 6 courses are involved in introduction the outcomes, but no one course supports its Mastery level. These discrepancies suggest a misalignment between intended learning outcomes and actual curriculum design, calling for a strategic reevaluation to ensure comprehensive and progressive learning across all PLOs. The same situation is concerning the PLO 7 and PLO 8, where there is not any activity (M) .

Referring to the variation intervals, it was observed that the contribution of courses to the "Introduction" (I) level fluctuates between 21% and 86%, while for the "Development" (D) level, the contribution ranges from 14.3% to 64%. This distribution analysis is instrumental in assessing both the existing gaps and the degree of alignment among courses, as well as in relation to the Program Learning Outcomes (PLOs). It provides critical insight into how effectively the curriculum scaffolds learning across different levels of competence.

Recognizing that the contribution of each course to the PLOs is influenced not only by its content, but also by its academic weight—expressed in credit hours—it becomes necessary to evaluate a more specific indicator. This indicator is defined as the ratio between the number of credits allocated to a course (or module) and the number of PLOs, which it supports. Figure 2 provides a visual representation of this metric, offering a clearer insight into its distribution and variation.

The significance of this ratio lies in its capacity to reveal the extent to which curriculum design aligns with intended program learning outcomes and operates with pedagogical efficiency. A lower ratio may indicate that a course is broadly aligned with multiple Program Learning Outcomes (PLOs), which could raise concerns about the depth and quality of learning achieved for each individual outcome. In contrast, a higher ratio may indicate a more concentrated and substantial engagement with fewer PLOs, which could enhance the achievement of specific learning outcomes if strategically positioned within the program. This measure thus serves as a critical diagnostic tool for evaluating the balance between content distributions and learning objective integration, informing potential curriculum adjustments to ensure both coherence and effectiveness.

The analysis of the results presented graphically in Figure 2 indicates that, the contribution of a single ECTS credit to the achievement of a PLO, varies significantly across courses. This indicator ranges from 0.375—corresponding to C13—to 1.17, in the case of C 9. It is important to note that the median value across all courses is 0.78. For the purposes of this analysis, the diploma (capstone or thesis component) was excluded due to its distinct nature; nonetheless, its specific indicator was calculated at 6, underscoring its focused contribution to only a limited number of PLOs.

These results serve as a foundational step toward a critical discussion about the current distribution of credits across courses. Specifically, they provide evidence that supports efforts to minimize unnecessary overlaps between courses and to enhance the achievement of Learning Outcomes through more intentional and coherent course design. Moreover, the Curriculum Mapping results offer an opportunity to assess not only the breadth but also the depth of each course's impact on the PLOs. A graphical representation of these findings is provided in Figure 3, serving as a foundation for further reflection on curriculum alignment and optimization.

The results indicate that the specific weight of each course's contribution to the PLOs falls within a range of 1.87% to 6.57%, with a median value of 5.16%. The lowest value is associated with Course 16, while the highest contributions are attributed to C 13, 14, 20, and the diploma. These findings have initiated critical faculty reflection on the asymmetry of course impact on the overall learning outcomes, considering factors such as the level of the study program (cycle), the academic sub-field, and the nature or academic typology of the course.

For a more comprehensive understanding, further analyses should include the assessment results of SLOs, together with a quantitative evaluation of inter-course gaps. This should consider course interdependencies, variations in teaching methodologies, and the alignment between instructional strategies and PLOs. Such multidimensional analysis would support data-driven decision-making aimed at continuous quality improvement in curriculum implementation.

4. Conclusion

The findings of this study highlight significant insights into the alignment between courses and Program Learning Outcomes (PLOs) within the examined curriculum. The application of the Mark-Release-Recapture (MRR) method, alongside curriculum mapping and credit distribution analysis, reveals several key observations and areas for potential improvement:

Asymmetry in course contributions: The analysis of course contributions to the PLOs demonstrates notable variability. Some courses contribute more significantly to the achievement of PLOs, while others contribute less, indicating an uneven distribution of responsibility across the curriculum. Specifically, certain PLOs (such as PLOs 1, 7, and 8) lack substantial course contributions, which raises concerns regarding the comprehensiveness and depth of learning in those areas. This suggests a need for a more balanced integration of learning outcomes across courses to ensure consistency

in student development.

Variation in credit contribution: The analysis of ECTS credits and their corresponding impact on PLOs reveals that each credit does not contribute equally to the achievement of PLOs across different courses. The range of contribution (from 0.375% to 6.57%) emphasizes the variability in course weight, suggesting that some courses are either overburdened with multiple learning outcomes or underutilized in terms of their alignment with program goals. The observed median value of 5.16% further underscores the disparity in course contributions, necessitating a reconsideration of credit distribution and the role each course plays in shaping student learning outcomes.

Curriculum optimization and policy implications: These findings provide an opportunity to reassess the curriculum structure, particularly in terms of balancing course load, ensuring alignment with PLOs, and improving the overall coherence of the program. Faculty discussions about the asymmetry in course impact on PLOs should consider the specifics of program cycles, academic sub-fields, and course types. Furthermore, the insights gained can inform institutional policies, especially regarding the improvement of student support services, curriculum design, and the refinement of admission policies. Strengthening the connection between academic support for incoming students and the Bachelor program's overall structure can significantly enhance student success and learning outcomes. While this study provides valuable insights into the curriculum's current state, future research should consider a more detailed evaluation of Student Learning Outcomes (SLOs) and their assessment results. Additionally, a quantitative evaluation of gaps between courses, considering interdependence and the diversity of teaching methods, would provide a more comprehensive view of curriculum effectiveness. Such analyses would allow for data-driven adjustments that enhance both the depth and breadth of student learning.

In conclusion, the results of this study serve as a foundation for the ongoing improvement of curriculum design and delivery. By addressing the identified disparities in course contributions to PLOs and optimizing credit distribution, the program can better align with its educational objectives, ultimately fostering a more cohesive and effective learning experience for students.

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