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A Comparative Study of Academic Performance in Map Projection Course

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ABSTRACT

BACKGROUND & CONTEXT

Proficiency in geomatics engineering is largely determined by how well students perform in technical courses like Map Projection. Student progress is measured against the academic years of 2017 and 2018, with performance patterns indicating steady but moderate achievement, especially in conceptual comprehension and computational skills.

PURPOSE OR GOAL

This research compares and analyses student performance in the Map Projection course from the 2017 and 2018 session years, with an emphasis on assessment efficacy, Course Learning Outcome (CLO) attainment, and grade distribution.

APPROACH OR METHODOLOGY

This study employs a quantitative methodology, examining past student grade distributions, CLO attainment rates, and assessment patterns taken from the Course Assessment Report (CAR) for 2017–2018. To assess trends in learning outcomes, grade movements, and student success is performed.

OUTCOMES

Results show that, with mean scores of 66.1% and 66.4%, respectively, there was a steady trend in academic achievement from 2017 to 2018. Although students did quite well on computational tasks (CLO2) and conceptual comprehension (CLO1), their critical thinking and analytical abilities (CLO4) fell short of expectations. There is a greater concentration in the B to B+ range, with few A-grades earned and few failures, according to grade distributions.

CONCLUSIONS

The findings indicate that, while student performance in 2017 and 2018 remained consistent, issues with critical thinking, programming abilities, and assessment alignment require more effort. Future study should examine the long-term impact of instructional improvements to improve student results in the Map Projection course.

KEYWORDS

Geomatics Engineering, Academic Performance, Map Projection; Education.

Introduction

Education in geomatics engineering is critical in providing students with the technical abilities needed to work with geospatial data, such as the use of coordinate systems, transformations, and projections. Future geomatics engineers must grasp and utilize map projection concepts. The Map Projection course (SGHU4893) is a key topic that teaches the fundamentals of translating three-dimensional Earth surfaces into two-dimensional representations. Students must understand projection concepts, mathematical calculations, and geographical transformations before they may progress to surveying, remote sensing, and geographic information systems (GIS) expertise. However, student success in this subject has varied throughout the years, with some cohorts outperforming others.

Student achievement in this course demonstrates their ability to handle sophisticated geospatial applications such as Geographical Information Science, Remote Sensing, and spatial data processing. However, academic achievement in this course is frequently inconsistent, raising concerns about the efficacy of present pedagogical approaches, evaluation systems, and student learning strategies. The purpose of this study is to compare student performance in the Map Projection course between the academic years 2017 and 2018, examine Course Learning Outcome (CLO) successes, and identify instructional elements that may contribute to or impede academic success.

The Map Projection course is vital in bridging theoretical knowledge with practical skills in geomatics. It covers a wide array of concepts, including geodetic datum, coordinate systems, mathematical modelling, and projection transformation algorithms. Despite its importance, past academic records show a trend of mixed student performance. Several issues frequently impact student achievement in this course. These include problems understanding abstract mathematical formulae, weak spatial thinking abilities, and a lack of interest in programming-related jobs. Instructors have also seen variances in CLO performance, notably in critical thinking and analytical activities. Understanding these trends is critical for developing effective interventions to improve teaching and learning outcomes in geomatics education.

The Map Projection course is a core subject in geomatics engineering programs, as it provides students with a deep understanding of:

- a. The mathematical principles behind geodetic and cartographic projections.
- b. The computational techniques used in transforming spatial data from one coordinate system to another.
- c. The application of projections in GIS, land surveying, and spatial analysis.

Despite its importance, many students struggle with theoretical concepts and computational aspects, particularly in solving complex mathematical equations and understanding the distortions introduced by different projection methods. Research suggests that students often experience difficulties in spatial thinking and geodetic computations, which can affect their ability to apply map projection principles effectively (Montello et al., 2018).

Student Performance

Student success in technical courses such as Map Projection is influenced by cognitive, instructional, and motivational variables. According to Ramasamy and Vakkil (2020), insufficient mathematics foundations correlate considerably to poor performance in geospatial topics. Students frequently fail to relate abstract concepts to real-world circumstances due to a lack of spatial reasoning abilities (Montello et al., 2018).

Instructional approaches have an important role. Traditional lectures may fail to effectively express complicated concepts, resulting in disinterest. Active learning techniques, such as project-based assessment and real-world applications, have demonstrated potential for boosting understanding and retention (Freeman et al., 2014). Assessment style also influences

performance; students succeed in assignments and projects but struggle in time-constrained tests (Boud, 2000).

Recent study has highlighted the advantages of integrating digital tools and interactive models in geospatial teaching. Battersby et al. (2020) suggest for GIS-based education to improve conceptual comprehension. Similarly, Buckley et al. (2019) discovered that using visualization tools dramatically increased students' understanding of coordinate transformation principles. These studies show that technologically enhanced learning settings can help geomatics students bridge the gap between theory and practice.

Learning difficulties in map projection courses have been attributed to topic difficulty, instructional style, and a lack of formative feedback. Students frequently struggle to integrate mathematical theory with its spatial application, particularly when exposed to traditional didactic teaching methods (Sweller, 1988). According to Paas and van Merriënboer (2019), guided problem-solving sessions and scaffolded education can help reduce cognitive strain.

Mathematical Proficiency

Coordinate transformations and geodetic computations are among the complicated mathematical topics used in map projection. Students with minimal mathematical backgrounds frequently struggle with these concepts, resulting in poor comprehension and performance. According to Ramasamy and Vakkil (2020), a lack of basic mathematics abilities makes it harder to master map reading and projection ideas. They discovered that pupils frequently lack the requisite mathematics abilities, limiting their ability to understand map projection principles successfully.

Spatial Reasoning Skills

Spatial thinking is required to comprehend how three-dimensional Earth features are depicted on two-dimensional maps. Students with limited spatial ability may find it difficult to comprehend and interpret map projections correctly. Ramasamy (2020) said that improving spatial skills through targeted training can enhance map reading abilities.

Instructional Strategies

Traditional lecture-based approaches may not effectively convey complex map projection concepts. Active learning strategies, such as hands-on activities and collaborative learning, have been shown to enhance understanding. Ramasamy (2020) demonstrated that activity-based training significantly improved map reading skills among elementary-level student teachers.

Motivation and Attitude

Students' motivation and attitudes towards map projection significantly influence their engagement and performance. A lack of interest or perceived relevance can lead to disengagement. Ramasamy and Vakkil (2020) noted that negative attitudes towards map-related topics contribute to learning difficulties.

Theoretical Framework

Understanding educational ideas can help build successful teaching tactics for map projection courses. Constructivism and experiential learning are especially relevant. This study is based on three main educational theories: Bloom's Taxonomy, Cognitive Load Theory, and Constructivist Learning Theory. Each theory provides a distinct perspective from which to evaluate course design, learning activities, and student involvement.

Bloom's Taxonomy

Bloom's Taxonomy, created by Bloom et al. (1956) and updated by Anderson and Krathwohl (2001), divides cognitive skills into six hierarchical levels: remembering, understanding,

applying, analyzing, evaluating, and creating. This taxonomy is commonly used to develop educational objectives and match them to relevant assessments.

In this study, Bloom's paradigm is used to examine how Course Learning Outcomes (CLOs) and related evaluations in the Map Projection course connect to cognitive growth. CLO1 (theoretical understanding of projections) focuses on memorizing and comprehending, whereas CLO2 and CLO3 (computational and practical abilities) emphasize applying and analyzing. CLO4 (critical thinking and research) involves higher-order cognitive processes such as evaluation and creation.

Cognitive Load Theory

Sweller (1988) developed Cognitive Load Theory (CLT), which examines how information is processed in the human brain and underlines the limitations of working memory. It differentiates among three forms of cognitive load:

- a) Intrinsic Load : refers to the inherent complexity of the content.
- b) Extraneous Load : Cognitive work resulting from inadequate instructional design.
- c) Germane Load : Mental resources dedicated to learning and schema development.

The Map Projection course has a high inherent load due to its mathematical rigor and technological depth. CLT emphasizes the use of teaching strategies that decrease superfluous burden, such as step-by-step coaching, visual aids, practical examples, and simple coding tasks.

The theory also highlights the value of timing and segmenting material distribution. Redesigning examinations and lectures to better manage load can boost student performance, especially in high-stakes areas like CLO3 (coordinate transformations) and CLO4 (critical analysis).

Constructivist Learning

The constructivist learning theory, created largely by Vygotsky (1978) and Piaget (1972), holds that learners actively build knowledge via interaction with their environment and peers. The Zone of Proximal Development (ZPD) is central to Vygotsky's theory; it represents the gap between what a learner can do alone and what they can do with supervision.

This theory lends support to instructional practices in the Map Projection course, such as collaborative group work, project-based learning, and peer-assisted exercises. These tactics allow learners to participate in realistic projects that connect theoretical principles to real-world applications. Group assignments allow students to co-construct information while improving retention. The recurrent underperformance in CLO4 indicates that students may not be given enough directed opportunity to acquire higher-order abilities through social interaction. Using constructivist approaches more intentionally might improve performance in future cohorts.

Experiential Learning

Kolb's (1984) experiential learning theory stresses learning via experience, which includes actual experiences, introspective observation, abstract conceptualization, and active experimentation. In map projection classes, this might lead to hands-on mapping projects that encourage students to apply theoretical knowledge to real-world problems.

Integrating Educational Theories into Map Projection Instruction

These educational ideas can be used to solve the issues described in map projection courses.

Active Learning Strategies

Incorporating active learning strategies, such as problem-based learning and interactive simulations, is consistent with constructivist ideas and has been found to increase student engagement and knowledge of technical topics.

Scaffolding and Differentiation

Providing organized assistance (scaffolding) and customizing instruction to fit varied learning requirements can improve comprehension. This technique is consistent with Vygotsky's ZPD, which suggests that learners gain from work somewhat above their current ability, aided by help from more educated persons.

Formative Assessment

Implementing formative assessments, such as tests and project-based evaluations, provides timely feedback and supports knowledge construction. This approach aligns with constructivist principles, emphasizing active engagement and personalized learning.

Real-World Applications

Connecting theoretical principles with real-world applications can boost relevance and motivation. For example, including students in projects involving spatial data analysis for urban planning might demonstrate the actual use of map projection abilities.

Methodology

This section describes the research methodology, data collection methods, data analysis tools, and ethical issues used in this comparative assessment of student performance in the Map Projection course (SGHU4893) across the academic years 2017 and 2018. The methodology's goal is to guarantee that the findings are accurate, trustworthy, and useful to geomatics education teaching practices, assessment procedures, and overall student accomplishment. This study uses a comparative quantitative research approach to evaluate student performance across two academic years. A longitudinal technique is used to investigate: Trends in student grades, CLO achievement, and testing results.

- a. The influence of instructional practices and assessment techniques on learning outcomes.
- b. Key problems students confront when learning map projection ideas, computational methodologies, and analytical abilities.

Data Collection Techniques

Primary Data Source: Course Assessment Reports (CAR)

The main data source for this study is the 2017–2018 Course Assessment Reports (CARs), which contain:

1. Grade Distribution Data: Breakdown of student grades for 2017 and 2018.
2. Mean Score Analysis: Average student performance in assessments and final exams.
3. CLO Achievement Data: Attainment levels for CLO1 (conceptual knowledge), CLO2 (computational proficiency), CLO3 (application skills), and CLO4 (critical thinking).
4. Assessment Performance: Student scores in testes, assignments, projects, and final exams.

Table 1 shows the list of CLOs for Map Projection course from the course information statement.

Table 1: CLOs for map projection

No.	CLO
CLO1	Construct accurately relevant principles of various types of map projections
CLO2	Evaluate related map projections computation using related mapping equations.
CLO3	Build the coordinate transformation modules related to surveying and mapping applications in Malaysia
CLO4	Use systematic research methodology which related issues on map projections and coordinate systems in Malaysia.

Population and Sampling

The study focuses on students enrolled in the Map Projection course (SGHU4893) during the 2017 and 2018 academic years.

- Sample Size: 2017 (n = 42), 2018 (n = 41).
- Sampling Method: A census sampling approach is used since the entire student population from both cohorts is analysed.

Data Analysis Techniques

Descriptive Statistical Analysis

The first stage of analysis involves descriptive statistics, including:

- Mean and Standard Deviation: To determine overall performance consistency.
- Grade Distribution Comparison: To assess shifts in performance trends.
- CLO Achievement Analysis: To evaluate progress in conceptual understanding, computation, application, and critical thinking.

Result and Analysis

This section analyses student performance in the Map Projection course for the academic years 2017 and 2018, using the CAR reports. The research concentrates on grade distribution, mean scores, Course Learning Outcomes (CLO) achievement, and significant performance patterns.

Mean and Standard Deviation Analysis

The analysis of the mean and standard deviation for student performance in the Map Projection course provides deeper insight into the overall achievement levels and the consistency of academic performance across the 2017 and 2018 cohorts.

In 2017, the average score was 66.1%, while in 2018, it climbed slightly to 66.4%. This marginal improvement demonstrates a consistent performance trend across two academic years, demonstrating that educational techniques and assessment processes remained at the same degree of difficulty and effectiveness. The stability of the mean results indicates that students comprehended the course's fundamental topics and achieved a reasonable degree of proficiency. However, the little improvement raises concerns regarding the extent to which course changes or pedagogical practices used in 2018 actually improved learning results.

The standard deviation, while not expressly indicated in the CAR reports, may be estimated based on grade distribution patterns. In 2017, grades were mostly in the B and B+ range, with a few pupils earning A-s and none scoring below C+. This very narrow spread suggests a low standard deviation, implying that student performance is homogeneous, with the majority of pupils falling within a similar range. This may be viewed as a sign of a well-balanced course structure in which students typically fulfilled the minimal standards, but it also implies a lack of differentiation few students exceeded those expectations to get top grades.

Similarly, in 2018, the performance trend remained consistent, with a slightly higher presence of A- grades but still a concentration in the B range. This again points to moderate variability in scores, reflecting that while there may have been some slight improvement in higher-performing students, the overall spread remained modest. The implication here is that while the course successfully enabled the majority of students to meet learning objectives (especially CLO1 and CLO2), it may not have been as effective in challenging or supporting the top and bottom segments of learners, respectively. From a pedagogical standpoint, the minimal fluctuation in mean and the stable standard deviation over the two years suggests the need for more targeted interventions to stimulate higher performance and reduce underperformance in advanced tasks. This could involve adaptive teaching methods, differentiated assessments,

or personalized feedback, which address the diverse needs of learners more effectively and contribute to raising both the average and the range of academic achievement.

Grade Distribution Analysis

The grade distribution for the 2017–2018 academic session is shown in Table 2 as follows:

Table 2: Grade distribution

Grade	2017 (%)	2018 (%)
A+	0%	0%
A	0%	0%
A-	0%	29.3%
B+	35.7%	0%
B	42.9%	39%
B-	7.1%	29.3%
C+	14.3%	0%
Below C	0%	0%

The grade distribution study for the Map Projection course in the 2017 and 2018 cohorts shows a continuous trend of mediocre academic achievement. In both years, the majority of students received marks ranging from B to B+, with only a handful receiving A-s and none scoring worse than C+. This indicates that, while students displayed a basic comprehension of key topics, high academic brilliance was restricted, and few students were able to master higher-order abilities examined in the course.

The low number of top grades may indicate difficulties in CLO3 (programming and coordinate transformation) and CLO4 (critical thinking and analysis), both of which demand the use of theoretical knowledge to address real-world situations. Furthermore, the absence of failing marks suggests that baseline abilities were met, particularly in CLO1 and CLO2, which cover theoretical and computational principles.

Despite this consistency, the distribution indicates a lack of difference among higher scorers, probably due to homogeneous assessment tasks that do not challenge advanced learners. Future iterations of the course could explore tiered or open-ended exams to give more challenge and acknowledge success, while also assisting students who struggle with the applied components.

Course Learning Outcomes (CLO) Analysis

The attainment of CLOs in the Map Projection course serves as a key performance indicator. The results for CLO in 2017 and 2018 shows in Table 3

Table 3: Course Learning Outcomes (CLO) Attainment in 2017 amd 2018

CLO	2017 Attainment (%)	2018 Attainment (%)	Remarks
CLO1: Understanding Projection Principles	66%	69%	Moderate achievement, but some students struggled with theoretical clarity.
CLO2: Computational Proficiency	70%	81%	Significant improvement due to increased problem-solving exercises.
CLO3: Application in Coordinate Transformations	68%	68%	Stable but students needed more guidance in programming tasks.
CLO4: Analytical and Research Skills	57%	57%	Weakest CLO attainment; students needed more critical thinking practice.

The analysis of Course Learning Outcome (CLO) achievement for the Map Projection course in the 2017 and 2018 academic years provides valuable insights into the strengths and weaknesses of student learning in both cohorts. The CLOs aimed to improve geospatial knowledge from theoretical comprehension to the application of critical thinking and research abilities.

CLO1, which focuses on understanding the fundamental concepts of map projection, was reasonably successful in both years, with 66% in 2017 and 69% in 2018. This minor increase indicates that most students were able to retain and understand fundamental concepts such as projection types, geodetic datums, and coordinate systems. The steady achievement shows that lecture delivery and the usage of slides or notes were typically effective in promoting lower-order cognitive skills such as remembering and comprehending, which correspond to Bloom's first two stages.

CLO2, which demands students to use computational methods for map projection computations, saw a more substantial improvement: 70% in 2017 and 81% in 2018. This favourable trend is most likely due to the increased emphasis on hands-on projects and exams in 2018, which allowed students to frequently practice and improve their problem-solving skills. The improvement also indicates that teaching tactics such as guided exercises and working examples were effective in increasing student confidence and proficiency in using formulae and addressing projection-related difficulties. CLO2's congruence with Bloom's Taxonomy's "applying" and "analysing" levels lends credence to the efficacy of these tactics in fostering mid-level cognitive involvement.

CLO3, which dealt with the construction and application of coordinate transformation modules, showed constant but moderate achievement over both years, with students scoring about 68%. This result indicates a common area of difficulty, particularly in programming jobs. Despite the availability of group tasks meant to model real-world transformation scenarios, many students lacked the necessary programming experience, resulting in lower performance in more technical components. According to Cognitive Load Theory, this might be the result of excessive intrinsic load and insufficient scaffolding to help students' working memory during learning. As a result, while students were able to execute some activities with assistance, many did not acquire full competency on their own.

CLO4, which focuses on evaluating map projection challenges and offering solutions through research or critical thinking, had the lowest achievement for both years (57%). This finding illustrates a continuing issue in acquiring higher-order thinking abilities, such as determining projection appropriateness and devising transformation solutions in a variety of geographic situations. Students frequently failed to defend their decisions or critically compare projection approaches, demonstrating deficiencies in their analytical reasoning and independent research ability. From a constructivist standpoint, this implies the need for more collaborative and inquiry-based learning methods, such as case studies, real-world problem solving, and organized peer review.

Conclusion

This study, has examined and analysed the trends in student performance over two academic years by focusing on grade distributions, Course Learning Outcome (CLO), mean scores, and standard deviation. Through this comparative approach, it becomes evident that while the Map Projection course maintained a consistent level of performance across both years, there are notable patterns and areas that warrant attention for instructional improvement.

The mean scores for 2017 and 2018 were relatively stable, recorded at 66.1% and 66.4% respectively, suggesting that the overall level of student understanding and achievement remained constant. The grade distributions also showed similar patterns, with the majority of students scoring within the B to B+ range and very few achieving higher distinctions such as A-. This narrow spread of scores, accompanied by low standard deviations, indicates that the cohort performances were homogenous. While this reflects a level of success in meeting the

minimum course expectations, it also implies a limitation in promoting higher-order learning and academic excellence.

When analyzed through the lens of CLO attainment, the findings provide further clarity. CLO1 (understanding map projection principles) and CLO2 (computational skills) were satisfactorily achieved in both years, demonstrating that students were generally able to grasp fundamental concepts and perform mathematical calculations related to map projections. This success may be attributed to structured lectures, guided assignments, and assessment designs that targeted lower to mid-level cognitive skills.

However, CLO3 (programming and application of coordinate transformations) and CLO4 (critical thinking and analysis) were moderately and weakly attained, respectively. Students faced significant challenges with tasks that required the integration of theoretical knowledge into practical applications, particularly those involving programming logic and analytical thinking. The persistent underperformance in CLO4 in both years (57% attainment) indicates a gap in fostering higher-order cognitive abilities such as evaluation, synthesis, and independent reasoning. These outcomes align with the literature, which emphasizes the importance of active learning, cognitive load management, and constructivist practices in technical education. The study recommends enhanced active learning strategies, scaffolded problem-solving exercises, and assessment adjustments to better support student learning. Future research should focus on evaluating the long-term impact of instructional changes to further improve student outcomes in the Map Projection course.

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