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Outcome based teaching of linear programming for economics students: A conceptual instructional design framework

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ABSTRACT

This manuscript develops a conceptual instructional design framework for teaching Linear Programming to economics students under the ASEAN University Network - Quality Assurance (AUN-QA) approach. The study is not an empirical classroom intervention and does not claim to statistically demonstrate the effectiveness of the proposed measures. Instead, it adopts a design-oriented conceptual approach based on analysis of AUN-QA requirements, programme learning outcomes, course learning outcomes, the Linear Programming course structure, relevant literature on constructive alignment and active learning, and reflective teaching experience. The analytical procedure consisted of identifying recurrent pedagogical challenges in Linear Programming instruction, mapping these challenges to course learning outcomes, selecting theoretically justified instructional strategies, and specifying assessment evidence that can support outcome monitoring. The resulting framework proposes three mutually connected measures: Kolb-based experiential learning for modelling economic optimisation problems, visualisation-supported instruction for the simplex algorithm, and project-oriented assignments for authentic economic applications. The main contribution of the manuscript is an explicit alignment matrix linking learning difficulties, course learning outcomes, teaching and learning activities, and assessment evidence. The framework is intended to guide instructors, curriculum designers, and quality assurance practitioners in designing outcome-based Linear Programming instruction. Future empirical studies should validate the framework through classroom data, rubric-based assessment, pre-test and post-test designs, student feedback, and analysis of learner differences.

Keywords: learning outcomes, ASEAN University Network Quality Assurance, constructive alignment, linear programming, economics students, instructional design framework

INTRODUCTION

The ASEAN University Network (AUN) was established in 1995 as a regional network of ASEAN universities. The ASEAN University Network - Quality Assurance (AUN-QA) framework subsequently became an important reference for higher education quality assurance in Southeast Asia. At programme level, the AUN-QA approach requires intended learning outcomes to be coherent, measurable, and aligned with teaching, learning, assessment, and continuous improvement processes (ASEAN University Network, 2020). For Vietnamese universities, this approach has encouraged programmes to move from content coverage toward outcome-based curriculum design.

However, implementing AUN-QA at the level of a specific course remains a challenging task. It is not sufficient for a syllabus to list programme learning outcomes (PLOs) and course learning outcomes (CLOs). Lecturers must design teaching and assessment activities that allow students to perform the intended cognitive and professional actions and must produce credible evidence that the stated outcomes are being addressed. This issue is especially important in mathematics-intensive service courses for economics students, where mathematical procedures must be connected with economic interpretation and decision making.

Linear Programming is a compulsory and important course in many economics, finance, banking, management, and business programmes. The course provides a mathematical basis for optimisation, resource allocation, production planning, transportation, investment allocation, and managerial decision making. Nevertheless, teaching Linear Programming to economics students presents specific pedagogical challenges. Many students can imitate worked examples but have difficulty translating an economic context into decision variables, objective functions, and constraints. Stevens and Palocsay (2004) identified linear programming formulation as a translation problem and proposed breaking the formulation process into explicit steps. This is directly relevant to economics students because the modelling task requires them to convert verbal business situations into measurable quantities and mathematical relations.

A second challenge concerns the simplex algorithm. Students often treat the simplex method as a sequence of mechanical tableau operations without understanding the optimisation logic behind pivots, adjacent feasible solutions, and movement toward optimality. Recent work on GILP, an interactive tool for visualising the simplex algorithm, emphasises that the mechanics of the simplex algorithm can obscure its geometric interpretation and that visualisation can help connect algebraic steps with geometric meaning (Robbins et al., 2023). Earlier work on Visual LinProg also showed the pedagogical potential of animation and visualisation in mathematical programming instruction (Lazaridis et al., 2007).

A third challenge is transfer. Traditional exercises often use simplified numerical problems and focus on obtaining the final answer. Such exercises may not produce sufficient evidence of students' ability to collect data, justify assumptions, formulate constraints, interpret solutions, communicate findings, and collaborate. This limitation is problematic under AUN-QA because outcome-based education requires evidence not only of procedural correctness but also of broader competencies such as problem solving, communication, self-directed learning, and teamwork. Spreadsheet-based modelling has been suggested as a practical bridge between modelling and professional decision contexts in operations research education (Thiriez, 2001), while project-based learning has been shown to support higher education learning outcomes when assessment criteria and artefacts are clearly specified (Guo et al., 2020).

Although previous studies have addressed outcome-based education, active learning, visualisation, and project-based learning, there remains a need for a course-level framework that explicitly maps the teaching of Linear Programming for economics students to AUN-QA-oriented outcome evidence. Existing literature often treats these instructional approaches separately. Less attention has been given to how they can be integrated into a coherent instructional design in which each measure addresses a specific learning difficulty, supports particular CLOs, and generates assessment artefacts that can be used for continuous improvement.

The present manuscript addresses this gap by developing a conceptual instructional design framework for the Linear Programming course. The framework is intended for instructors who teach Linear Programming, students who need structured support in modelling and interpretation, curriculum designers who must align course activities with programme outcomes, and quality assurance practitioners who require transparent evidence of outcome attainment. The manuscript does not report empirical evidence of classroom effectiveness. Instead, it provides a theoretically grounded framework and specifies how the framework could be validated in future empirical studies.

The guiding research question is: How can a Linear Programming course for economics students be designed as an outcome-based instructional framework aligned with AUN-QA standards, constructive alignment, and relevant research on mathematical modelling, visualisation, and project-based learning?

LITERATURE REVIEW

Outcome-Based Education and AUN-QA Alignment

Outcome-based education begins with the specification of what learners should be able to know, do, and demonstrate after completing a course or programme. The AUN-QA programme-level framework emphasises that programme learning outcomes should be aligned with curriculum structure, teaching and learning strategies, student assessment, and continuous improvement mechanisms (ASEAN University Network - Quality Assurance, 2020). In this perspective, a course is not merely a container of subject matter. It is a designed learning environment in which content, activities, assessment tasks, and evidence artefacts must work together to support the intended outcomes.

Constructive alignment provides a theoretical foundation for this logic. Biggs (1996) argued that intended learning outcomes should determine both teaching activities and assessment tasks, so that students are required to perform the cognitive actions specified in the outcomes. In Linear Programming, this means that if a CLO states that students should be able to model economic problems, assessment must require students to formulate and justify decision variables, constraints, and objective functions, not simply reproduce a standard algorithm. Similarly, if a CLO concerns applying the simplex algorithm, students should be assessed on procedural accuracy, conceptual interpretation, and explanation of the algorithmic steps.

However, the literature on outcome-based education often remains at programme or curriculum level. Its practical implementation in a mathematically intensive course requires more detailed translation from PLOs and CLOs into teachable activities and observable evidence. This limitation motivates the need for a course-level instructional design framework.

Learning Difficulties in Linear Programming and Operations Research instruction

One recurrent difficulty in Linear Programming instruction is formulation. Stevens and Palocsay (2004) argued that students often struggle with the translation from word problems to linear programming models and proposed a translation approach that decomposes formulation into smaller, well-defined steps. This finding is important because Linear Programming formulation is not only an algebraic exercise; it requires students to identify measurable quantities, interpret contextual restrictions, and express economic goals mathematically.

Realistic and contextualised approaches also appear relevant. Octaria et al. (2023), in a systematic literature review on learning Linear Programming through Realistic Mathematics Education, highlighted the role of real-world contexts in supporting students' understanding of Linear Programming concepts. This literature supports the use of contextualised modelling tasks. However, realistic contexts alone do not guarantee outcome alignment; they must be connected to explicit CLOs, guided modelling processes, and assessment evidence.

Operations Research education has also emphasised the value of spreadsheet-based modelling. Thiriez (2001) argued that spreadsheets can function both as teaching tools for modelling and professional tools for business decision models. This is particularly relevant for economics students, who often need to connect mathematical formulations with practical decision tools. However, spreadsheet use must be accompanied by conceptual explanation and assessment criteria; otherwise, students may rely on software outputs without understanding the modelling assumptions.

The simplex method presents another difficulty. Lazaridis et al. (2007) developed Visual LinProg as a web-based educational software for Linear Programming, while Robbins et al. (2023) developed GILP to connect the mechanical steps of the simplex algorithm with their geometric interpretation. These studies support visualisation as an instructional direction. Nevertheless, visual tools by themselves do not constitute an outcome-based design unless they are integrated with prediction tasks, explanation prompts, solution logs, and assessment rubrics.

Experiential Learning, Visualisation, and Project-Based Learning

Kolb’s experiential learning theory conceptualises learning as a cycle involving concrete experience, reflective observation, abstract conceptualisation, and active experimentation (Kolb & Kolb, 2022). For Linear Programming instruction, this sequence is pedagogically appropriate because modelling begins with a concrete economic situation, proceeds through reflection and discussion, leads to mathematical abstraction, and requires application to new decision contexts. Recent literature also supports the use of experiential learning to increase student cognitive participation and critical thinking; however, Mertayasa et al. (2024) is a literature review with a broad educational scope, so it should be used to support the pedagogical rationale rather than as direct empirical evidence for Linear Programming instruction.

Visualisation in mathematics education supports the interpretation of abstract concepts and the coordination of multiple representations. Arcavi (2003) emphasised the role of visual representations in mathematical meaning making. In Linear Programming, visualisation can connect feasible regions, constraints, objective functions, tableau operations, and economic interpretation. Hegedus and Moreno-Armella (2009) further highlighted the importance of representation and communication infrastructures in mathematical learning. However, visualisation must be used carefully; students should be required to predict, explain, and justify algorithmic steps rather than passively observe animations.

Project-based learning is also consistent with outcome-based education because it can generate artefacts that resemble professional practice. Guo et al. (2020) reviewed project-based learning in higher education and emphasised student outcomes and measurement instruments, while Chen and Yang (2019) reported positive effects of project-based learning on student academic achievement in a meta-analysis. In the Linear Programming context, Bahri and Husna (2022) discussed project-based learning for solving industrial-world problems, while Hartono et al. (2025) reported that project-based cooperative learning improved students’ mathematical literacy in linear programming. However, the literature also implies that project-based learning requires transparent rubrics, credible data evidence, and clear assessment criteria (Vlachopoulos & Makri, 2024); otherwise, project activities may be engaging but weakly aligned with learning outcomes.

Learner Differences and Implications for Mathematics-Intensive Courses

Outcome-based teaching assumes that all students are supported in achieving intended outcomes, but students differ in prior knowledge, motivation, self-efficacy, and learning preferences. Yurt (2025) investigated the role of learning style in the relationship among task value, self-efficacy, and mathematics achievement, reporting that these relationships vary across learning styles. This study involved eighth-grade students and therefore cannot be treated as direct evidence for university-level Linear Programming. Nevertheless, it is useful for the discussion of learner differences: a Linear Programming framework should provide multiple forms of engagement, including contextual tasks, visual representation, collaborative work, and project application.

Research Gap

The reviewed literature provides important insights into outcome alignment, Linear Programming formulation, visualisation, spreadsheet modelling, experiential learning, and project-based learning. However, three limitations remain. First, many studies address general mathematics, STEM, or Operations Research education rather than a specific AUN-QA-aligned Linear Programming course for economics students. Second, studies on visualisation or project-based learning often focus on tools or methods without explicitly mapping them to PLOs, CLOs, and assessment evidence. Third, learner differences are rarely integrated into course-level outcome-based frameworks. Prior course-level work in Vietnamese universities has examined teaching approaches and mathematical competencies for economics students (Tran & Nguyen, 2018a, 2018b) but has not developed an AUN-QA-aligned instructional design framework for Linear Programming with explicit outcome evidence pathways. Therefore, the current manuscript develops a conceptual instructional design framework that explicitly links learning difficulties, CLOs, teaching activities, and assessment artefacts for Linear Programming instruction under AUN-QA.

METHODOLOGY: DESIGN-ORIENTED CONCEPTUAL STUDY

Research Design

This study is a design-oriented conceptual study. It is not an empirical classroom-based intervention study, and it does not include a statistical test of the effectiveness of the proposed instructional measures. The purpose is to develop a theoretically grounded instructional design framework for teaching Linear Programming to economics students in alignment with AUN-QA standards.

The design-oriented nature of the study means that its output is a structured framework rather than measured learning gains. The framework is evaluated conceptually through coherence with AUN-QA requirements, constructive alignment, relevant literature, the structure of the Linear Programming course, and practical feasibility for teaching. Empirical validation is identified as a necessary direction for future research.

Materials Analysed

The study analysed five groups of materials. First, AUN-QA programme-level requirements were examined, with attention to outcome formulation, curriculum alignment, teaching and learning strategies, assessment evidence, and continuous improvement. Second, the programme learning outcomes of the Finance-Banking programme were analysed to identify the relevant PLOs supported by the Linear Programming course. Third, the course learning outcomes and topic structure of the Linear Programming course were examined. Fourth, the literature on constructive alignment, Linear Programming instruction, experiential learning, visualisation, spreadsheet modelling, project-based learning, and learner differences was synthesised. Fifth, reflective teaching experience was used to identify typical learning bottlenecks, but it was not treated as empirical data from a formal classroom study.

Analytical Procedure

The analytical procedure consisted of six steps:

Step 1: Identify the relevant PLOs and CLOs. The study first examined how the Linear Programming course contributes to programme-level outcomes, especially problem solving, self-directed learning, teamwork, and communication.

Step 2: Identify key learning difficulties. Based on literature synthesis and reflective teaching experience, three major difficulties were identified: modelling economic situations, understanding simplex procedures conceptually, and transferring Linear Programming to authentic economic problems.

Step 3: Select theoretically justified instructional strategies. Kolb-based experiential learning was selected for modelling tasks, visualisation-supported instruction was selected for the simplex algorithm, and project-based learning was selected for authentic application.

Step 4: Map each strategy to CLOs. Each proposed measure was linked to specific CLOs, ensuring that instructional activities were not isolated teaching techniques but outcome-oriented design components.

Step 5: Specify assessment evidence. For each measure, the study identified evidence artefacts such as modelling worksheets, peer critique records, prediction and explanation prompts, simplex solution logs, project reports, data appendices, and presentation rubrics.

Step 6: Construct an alignment matrix. The final framework was organised as an alignment matrix connecting learning difficulty, instructional measure, CLO, teaching activity, assessment evidence, and expected artefact.

Design Criteria

The framework was developed according to four design criteria. Relevance means that each measure must address the content and learning outcomes of the Linear Programming course. Feasibility means that the measure can be implemented in normal teaching conditions for economics students. Goal-orientation means that the measure supports stated CLOs and PLOs. Evidence potential means that the measure can generate observable artefacts that can later be used for outcome monitoring and empirical validation.

DESIGN RESULTS: OUTCOME-BASED INSTRUCTIONAL FRAMEWORK

Programme and Course Outcome Context

Tables 1 and **2** present the learning outcomes developed in accordance with AUN-QA standards, using the Finance and Banking major as an illustrative case for economics-related programmes. Table 1 presents the programme learning outcomes, while Table 2 specifies their course-level alignment through the learning outcomes of Linear Programming. This alignment demonstrates the coherence among programme outcomes, course outcomes, and Bloom's taxonomy within an outcome-based instructional framework.

Table 1. Output standards of the Finance-Banking training programme according to AUN-QA standards (Lac Hong University, 2024)

PLOs	Output standards
PLO1	Apply basic knowledge of natural sciences, social sciences, and economics to solve problems.
PLO2	Apply knowledge of accounting, finance, and banking to solve practical problems.
PLO3	Effectively apply digital technology in work.
PLO4	Work effectively in teams.
PLO5	Build effective financial solutions.
PLO6	Demonstrate the ability to engage in lifelong learning.
PLO7	Build a start-up project.
PLO8	Adhere to standards of professional ethics and practise social responsibility.
PLO9	Communicate ideas effectively through written, visual, and verbal communication.

Table 2. Course learning outcomes of Linear Programming for economics students (Lac Hong University, 2024)

CLOs	Course learning outcomes	Bloom domain / level	Related PLOs
CLO1	Model economic problems.	Knowledge (3)	PLO1
CLO2	Apply the simplex algorithm to solve economic problems.	Knowledge (3)	PLO1
CLO3	Apply the dual algorithm to solve transportation problems.	Knowledge (3)	PLO1
CLO4	Read, research, and self-study advanced sections of the course.	Skills (3)	PLO6
CLO5	Demonstrate a positive attitude and cooperate with teachers and other students during learning and group assignments.	Attitude (4)	PLO4

Alignment Matrix of the Proposed Framework

Table 3 presents the alignment matrix of the proposed instructional framework. It maps instructional measures onto identified learning difficulties, supported CLOs, learning activities, and assessment evidence, thereby demonstrating the constructive alignment of the framework.

Table 3. Alignment matrix of instructional measures, learning difficulties, outcomes, activities, and assessment evidence

Measure	Learning difficulty addressed	CLOs supported	Teaching and learning activities	Assessment evidence / expected artefacts
Measure 1: Kolb-based experiential modelling	Students imitate examples but struggle to translate economic contexts into variables, objectives, and constraints.	CLO1, CLO5	Opening economic scenario; prior knowledge activation; group discussion; modelling worksheet; peer critique; guided abstraction; application to a new problem.	Completed modelling worksheet; explanation of decision variables and constraints; peer discussion notes; revised mathematical model; instructor feedback.
Measure 2: Visualisation-supported simplex instruction	Students perform tableau operations mechanically and do not connect pivot steps with optimisation meaning.	CLO2, CLO3	Visual diagram of simplex process; prediction and explanation prompts; stepwise tableau construction; comparison of algebraic and geometric interpretations.	Simplex solution log; pivot-step explanation; prediction and explanation responses; interpreted optimal solution.
Measure 3: Project-oriented economic application	Students solve routine exercises but lack experience applying Linear Programming to authentic economic problems.	CLO1, CLO2, CLO4, CLO5	Group project; selection of an authentic economic unit; data collection; model formulation; simplex solution; economic interpretation; report and presentation.	Project report; data evidence appendix; spreadsheet or simplex tableau file; presentation; rubric scores for data credibility, model correctness, computation, interpretation, and communication.

Measure 1: Kolb-Based Experiential Learning for Modelling Economic Optimisation Problems

The first measure applies Kolb’s experiential learning cycle to the teaching of Linear Programming modelling. The measure is designed to address CLO1 by helping students move from a concrete economic situation to an explicit mathematical model. The design begins with an opening problem, encourages reflection and discussion, guides students toward abstraction, and ends with application to a new modelling task (See **Figure 1** and **Table 4**).

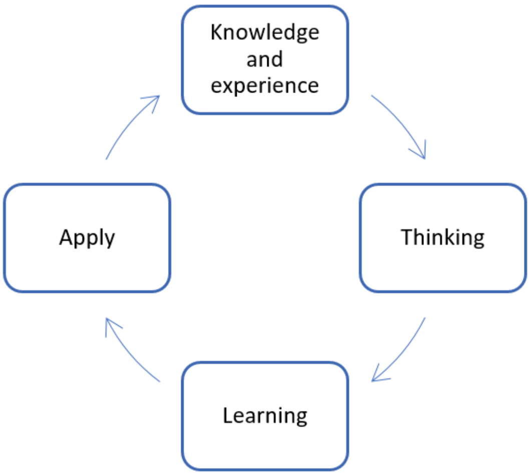

Figure 1. Experiential teaching model for the Advanced Mathematics course (Tran, 2019; Tran & Nguyen, 2020)

Table 4. Details of work content according to the steps of the experiential learning model

No.	Step of the process	Work to be done
1	Knowledge and experience	State the opening problem; ask questions that recall relevant previous lessons; ask questions that mobilise known knowledge.
2	Thinking / reflection	Ask provocative questions; guide students to discuss them in pairs or small groups; distribute worksheets for small-group completion.
3	Learning / abstraction	Summarise student answers; guide debate between groups and individuals; help students present the new knowledge content derived from the opening lesson.
4	Application	Assign simple application problems; assign higher-level application problems; consolidate knowledge through applied exercises.

Illustration of the steps of the experiential learning process through the lesson: “Modeling an optimal production problem”

Step 1: ***Knowledge and Experience***

The instructor presents a scenario containing the lesson content and poses appropriately challenging questions to help students activate their prior knowledge and personal experience to successfully complete the learning task.

Example Problem: A furniture manufacturing facility plans to produce three types of products: tables, chairs, and cabinets. The labour requirements, production costs, and selling prices for each product are estimated as shown in **Table 5** (Tran, 2023).

Table 5. Data for the illustrative optimal production problem

Factor	Table	Chair	Cabinet
Labour (man-days)	2	1	3
Production cost (thousand VND)	100	40	250
Selling price (thousand VND)	260	120	600

Problem Statement: Formulate a mathematical model to determine the number of units to produce for each product type such that production constraints are satisfied and total revenue is maximised. The facility has a total labour capacity of 500 man-days and a production budget of 40 million VND. Additionally, the number of tables and chairs must maintain a ratio of 1:6.

Step 2: ***Reflection***

The instructor divides the class into small groups, encouraging students to work collaboratively, present their own ideas, listen actively, defend their opinions, and critique others constructively. The interaction among group members serves as a miniature social environment, fostering understanding and mutual respect, which helps students become more open in communication. After group discussions, a representative from each group presents their ideas to the entire class. This process of sharing and feedback continues, with the instructor observing, providing comments, evaluations, and praise.

During this reflection step, the instructor poses open-ended questions based on the introductory problem in the lesson “Modeling an Optimal Production Problem”:

1. Identify the requirements of the problem.

Expected answer: Determine the number of tables, chairs, and cabinets the facility should produce. The instructor guides students to define decision variables: let x_1, x_2, and x_3 represent the numbers of tables, chairs, and cabinets to produce, respectively, where $x_1, x_2, x_3 \geq 0$ and are integers.

2. Determine the total labour and production cost required to produce the quantities of each product.

Expected answer: Labour: $2x_1 + x_2 + 3x_3$ (man-days). Cost: $100x_1 + 40x_2 + 250x_3$ (thousand VND).

3. What conditions must labour and cost satisfy to avoid exceeding production constraints?

Expected answer: Labour constraint: $2x_1 + x_2 + 3x_3 \leq 500$. Cost constraint: $100x_1 + 40x_2 + 250x_3 \leq 40{,}000$.

4. Considering production requirements and product characteristics, what condition must the number of tables and chairs satisfy?

Expected answer: The ratio must satisfy $x_2 = 6x_1$.

5. Calculate the facility’s expected total revenue.

Expected answer: $Z = 260x_1 + 120x_2 + 600x_3$ (thousand VND).

6. What condition is required to maximise the facility’s total revenue?

Expected answer: Z must reach its maximum value. The instructor reinforces: Therefore, the mathematical model of the problem is:

Maximise $Z = 260x_1 + 120x_2 + 600x_3$

subject to $2x_1 + x_2 + 3x_3 \leq 500$, $100x_1 + 40x_2 + 250x_3 \leq 40{,}000$, $x_2 = 6x_1$

$x_1, x_2, x_3 \geq 0$ (integers).

This is the mathematical model of a linear programming problem.

Step 3: ***Learning***

Building on prior knowledge and experience, through reflection, peer discussion, and instructor feedback, students need dedicated time to interact with the textbook, reference materials, and lectures. This allows students to grasp the general principles of the lesson and articulate their understanding clearly. For example, in the case of the previous problem, the instructor poses questions that guide students step by step in formulating the linear programming model.

Step 4: ***Application***

Once students have understood the core content of the lesson, they need to apply it in new situations, which helps them practice and master the steps of formulating a linear programming problem. For instance, in this step, the instructor assigns students the following exercise: formulate the mathematical model for the problem below (Tran, 2023):

Example problem: Optimal production planning for a textile factory

A textile factory plans to produce three types of fabric: A, B, and C. The raw materials available are cotton, kate, and polyester, with corresponding quantities of 5, 4, and 6 tons, respectively. The consumption of each type of fibre (kg) per meter of fabric and the selling price (thousand VND/m) for each fabric type are shown in **Table 6**.

Table 6. Input data for the textile production planning model

Material	A	B	C	Selling Price (thousand VND/m)
Cotton	0.2	0.2	0.1	125
Kate	0.1	0.2	0.1	140
Polyester	0.1	0.1	0.2	110

Mathematical Model: Optimal Production Planning for the Textile Factory. The objective is to determine the number of meters of each fabric type A, B, and C to produce so that total revenue is maximised while ensuring production constraints are satisfied. According to market research, the production quantities of fabrics A and B must be equal.

The evidence generated by this measure is not merely the final model. It includes the modelling worksheet, students' explanations of variables and constraints, peer critique, and the revised formulation. These artefacts can be used to evaluate whether students are achieving CLO1.

Measure 2: Visualisation-Supported Instruction for the Simplex Algorithm

The second measure supports students in applying the simplex algorithm while understanding its optimisation meaning. The measure is designed to address CLO2 and CLO3. It uses visual representations, stepwise tableau construction, and prediction and explanation prompts. Before performing a pivot, students should be asked to predict the next step and explain why the entering and leaving variables are selected.

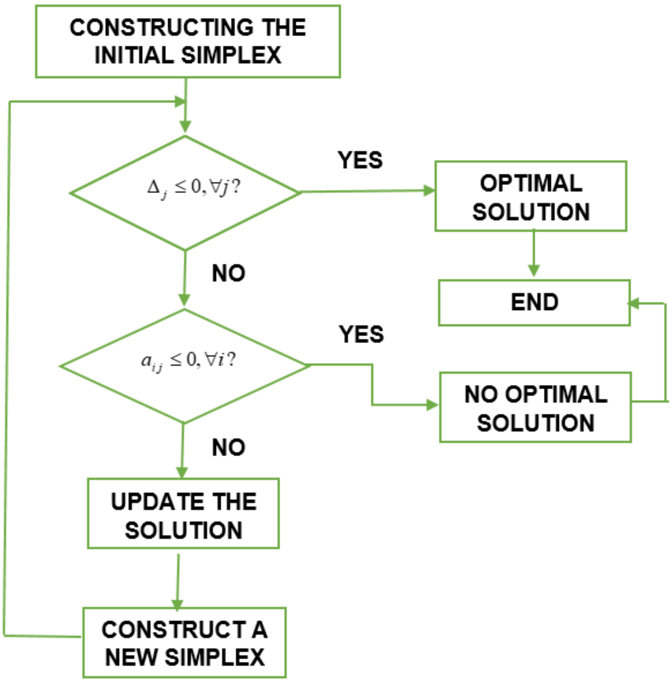

Figure 2. Visual diagram of the simplex algorithm (Tran, 2023)

For a Linear Programming problem in standard form (Dantzig, 1963; Vanderbei, 2020), students construct the initial simplex tableau, examine optimality conditions, identify whether a feasible improving direction exists, update the solution through pivoting, and construct a new simplex tableau. The key pedagogical point is that the tableau is not taught as a purely mechanical routine. Students are required to explain the economic and mathematical meaning of each step.

The expected evidence artefacts include simplex solution logs, pivot-step explanations, prediction responses, and interpretation of the optimal solution. These artefacts allow instructors to assess whether students understand both the procedure and the meaning of the algorithm.

Measure 3: Project-Oriented Assignments for Authentic Economic Applications

The third measure enhances project-oriented assignments so that students can apply Linear Programming to authentic economic problems. This measure is designed to support CLO1, CLO2, CLO4, and CLO5. It also contributes to programme-level outcomes related to teamwork, communication, and lifelong learning.

Project theme: Students develop an optimal production or service plan for an authentic economic unit and solve the resulting Linear Programming model using the simplex method.

Project objective: Students collect real or documented data, formulate a Linear Programming model, convert it to standard form, solve it with the simplex method or an equivalent documented computation process, and interpret the optimal solution from an economics and management perspective.

Context selection requirements: Students select an existing economic unit such as a household business, production facility, internship enterprise, or service shop. The selected context must include at least two products or services and at least two scarce resources, such as labour hours, machine hours, materials, budget, storage capacity, or capital limits.

Data collection requirements: For each product or service, students collect selling price, cost, and profit information. For each resource, students document unit consumption by product and total available resource in the planning period. If market constraints exist, such as maximum demand or minimum contracted volume, students must document them. Evidence should include at least two types of supporting material, for example quotations, photos of price lists, invoices, inventory slips, wage sheets, or technical norms.

Required submissions: Students submit an 8-to-12-page report, an appendix containing collected data evidence, and an Excel file or simplex tableau file documenting computations. They also present and defend their model and interpretation. As shown in **Table 7**, the project-oriented assignment is structured around knowledge, skills, and attitude objectives, with each domain aligned to the relevant CLOs.

Table 7. Learning objectives of the project-oriented assignment

No.	Objective	Content	Learning outcomes
1	Knowledge	Consolidate, supplement, and enhance knowledge of modelling and solving Linear Programming problems applied in economics.	CLO1, CLO2
2	Skills	Develop modelling, problem-solving, teamwork, and presentation skills.	CLO4
3	Attitude	Actively and independently engage in learning; demonstrate collaboration and responsibility toward the group and the class.	CLO5

The assessment rubric should cover data credibility, correctness of the mathematical model, accuracy of the simplex procedure, quality of economic interpretation, communication quality, and evidence of collaboration. This rubric is essential because project-based learning can become weakly aligned if assessment criteria are not transparent.

DISCUSSION

The proposed framework should be interpreted as a theoretically grounded instructional design, not as empirical proof of effectiveness. Its value lies in the explicit alignment among learning difficulties, CLOs, teaching activities, and evidence artefacts. This directly responds to the AUN-QA expectation that programmes demonstrate how learning outcomes are supported and assessed rather than merely declared.

Measure 1 addresses the modelling difficulty identified in the Linear Programming literature. Stevens and Palocsay (2004) treated LP formulation as a translation problem and argued for breaking formulation into explicit steps. The Kolb-based measure proposed in this manuscript is compatible with that view because it guides students from economic experience to reflection, abstraction, and application. The measure is also supported by experiential learning theory (Kolb & Kolb, 2022) and by recent literature suggesting that experiential learning can promote cognitive participation and critical thinking (Mertayasa et al., 2024), consistent with broader evidence that active learning improves student outcomes in STEM contexts (Freeman et al., 2014). However, this support is theoretical and indirect. The current manuscript does not measure whether the measure improves students' modelling performance.

Measure 2 addresses the risk that students learn the simplex algorithm as a mechanical tableau routine. Visualisation-supported instruction is consistent with Arcavi's (2003) argument that visual representations support mathematical meaning making. It is also consistent with Linear Programming visualisation tools such as Visual LinProg (Lazaridis et al., 2007) and GILP (Robbins et al., 2023), which aim to connect algorithmic mechanics with interpretation. The additional contribution of the present framework is to connect visualisation with assessment evidence, such as prediction and explanation prompts. Nevertheless, the framework does not yet compare visualisation-supported instruction with traditional simplex teaching through experimental data.

Measure 3 extends the course from routine exercises to authentic economic application. This is consistent with project-based learning literature in higher education, which emphasises student artefacts, authentic tasks, and measurable learning outcomes (Guo et al., 2020). Chen and Yang (2019) reported positive effects of project-based learning on achievement across studies, while Bahri and Husna (2022) and Hartono et al. (2025) provided evidence of project-based learning improving student outcomes in Linear Programming contexts. However, project-based learning only becomes outcome-based when assessment is supported by transparent rubrics and credible artefacts. Therefore, the present framework specifies project reports, data appendices, computation files, presentations, and rubric criteria as evidence.

The framework also needs to account for learner differences. Yurt (2025) showed that the relationship among task value, self-efficacy, learning style, and mathematics achievement can vary across learning styles. Because that study involved eighth-grade students, it should not be overgeneralised to university economics students. Even so, it suggests that outcome-based Linear Programming instruction should not rely on a single representation or activity type. The combination of contextual modelling, visualisation, collaborative work, and project application may provide multiple access points for students with different strengths, motivations, and prior knowledge.

The principal limitation of the manuscript is that it does not provide empirical evidence of effectiveness. It does not report student performance data, CLO attainment scores, pre-test and post-test comparisons, rubric reliability, or student feedback. Therefore, claims about effectiveness must remain cautious. The framework is a design proposal that requires future validation.

Future empirical research should implement the framework in actual Linear Programming classes and examine its effects through a quasi-experimental or design-based research design. Possible evidence includes pre-test and post-test measures aligned with CLO1, CLO2, and CLO3; rubric-based scoring of modelling tasks and projects; inter-rater reliability analysis for rubric scores; student feedback on modelling, visualisation, and project activities; and analysis of moderators such as prior mathematical knowledge, self-efficacy, task value, and learning style. Such research would allow the proposed framework to move from conceptual design to empirically supported instructional practice.

CONCLUSION

This manuscript develops a theoretically grounded conceptual instructional design framework for teaching Linear Programming to economics students under AUN-QA standards. The framework is built on AUN-QA outcome alignment, constructive alignment, literature synthesis, course outcome analysis, and reflective teaching experience. It proposes three integrated instructional measures: Kolb-based experiential modelling, visualisation-supported simplex instruction, and project-oriented economic application.

The main contribution of the study is the explicit alignment of learning difficulties, course learning outcomes, teaching and learning activities, and assessment evidence. This alignment can support instructors in designing more coherent Linear Programming lessons, help students connect mathematical procedures with economic meaning, assist curriculum designers in linking course activities to programme outcomes, and provide quality assurance practitioners with a clearer evidence pathway.

The manuscript does not claim that the proposed measures have been empirically proven effective. Its limitation is the absence of classroom data, statistical testing, and measured CLO attainment. Future studies should validate the framework through empirical implementation, pre-test and post-test designs, rubric-based assessment, inter-rater reliability, student feedback, and analysis of learner differences. Only after such validation should strong claims about effectiveness be made.

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