

A Pathway for Developing Digital Literacy in Economics Programs at Engineering-Oriented Universities

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DOI: 10.64649/yh.eg.issn3078-4794.20260413

Abstract: Digital technologies have changed both the data basis of economic activity and the way economic problems are analyzed. This conceptual paper asks how economics programs in engineering-oriented universities can develop students' digital literacy for economic analysis. Drawing on research on digital literacy and on instructional design for complex learning, it distinguishes three levels of digital literacy in economics (general, professional, and integrated application literacy) and argues that each level depends on the one below it. It then argues that engineering-oriented universities have strong mathematics and computing resources, but that these sit in modules the economics program can hardly adapt, so students' technical skills stay weakly connected to economic problems. The paper proposes a three-step pathway: define literacy as observable analytical performance, link courses through common economic problems, and place the resulting tasks in regular teaching. Coordination responsibility, faculty collaboration, student roles, and curriculum revision support the pathway.

Keywords: digital literacy; economics education; engineering-oriented universities; integrated application literacy; complex learning

0. Introduction

Digital technologies are changing how economic activity is organized and how it is studied. Data now underpin both economic decisions and economic research. Administrative records, platform transactions, and text have become routine sources of evidence, and students meet them in coursework. Higher education policy in China has also put growing weight on digital skills in undergraduate training. Digital literacy is no longer a concern of technology-related fields alone. It is a basic capability for students in every discipline, and each discipline has to work out what it means in practice.

For economics, the answer cannot stop at operating software. Economists use data to identify phenomena, test relationships, and support decisions, so students must also understand what the data represent and what conclusions they can support. The question takes a particular form in engineering-oriented universities. Their economics students usually have more contact with mathematics, computing, and engineering than students in economics- or finance-oriented universities, yet contact does not guarantee that students can turn these resources into economic analysis. This paper asks how economics programs in engineering-oriented universities can connect their existing digital resources to economics education, so that students develop the digital literacy needed to analyze economic problems.

The paper is conceptual. It relies on argument and published research. Section 1 reviews the literature and states the contribution. Section 2 defines three levels of digital literacy in economics. Section 3 analyzes the curriculum context and explains why courses remain weakly connected. Section 4 proposes a development pathway, Section 5 the mechanisms that support it, and Section 6 concludes.

1. Literature Review and Contribution

1.1 Digital Literacy and Its Disciplinary Context

Early definitions treated digital literacy as the ability to access, understand, and use information and technology in digital environments. Later work described it as a multidimensional capability that goes beyond technical skills^[1]. Subsequent research further proposed that it encompasses technical, cognitive, and social-emotional dimensions^[2], while a comparison of eight competency frameworks identified cognitive, critical, technical, social, emotional, and projective skills^[3]. Chinese research describes a similar movement, from a focus on tool skills, through situated competence, toward integrated literacy^[4]. Most of this work treats digital literacy in general digital environments or in higher education at large. It says little about how the concept should be tied to disciplinary knowledge and professional judgment within a particular field.

1.2 Developing Digital Literacy

Research on digital literacy in higher education has moved from general skills training toward discipline-specific learning. Reviews of digital competence assessment call for more valid and reliable instruments^[5]. The call matters for economics: without a shared description of what students should be able to do, each course assesses only its own part. In economics education, some studies have shown how Kaggle prediction competitions can be integrated into undergraduate econometrics courses^[6], and how applied econometrics projects can be designed for undergraduates^[7]. Both bring data-based practice into econometrics teaching, but each is confined to a single course or project. How digital capabilities accumulate across a sequence of courses is not addressed.

Instructional design research on complex learning offers a way to approach this question. The four-component instructional design (4C/ID) model rests on the view that complex skills depend on integrating and coordinating constituent skills, so instruction should be organized around whole tasks, with part-task practice in a supporting role. The model separates information that supports learning across tasks from information needed at the moment a routine step is performed, and it orders tasks from simple to complex, with support reduced as learners advance^[8]. The studies reviewed here do not apply this view across courses. Two gaps follow. General frameworks do not specify what economics requires in particular, namely the ability to interpret the economic meaning of data and to judge what conclusions it supports. And work on developing digital literacy has not asked how a program can arrange its courses so that constituent skills are practiced together on the same economic problem.

The paper makes three contributions. It defines three levels of digital literacy for economics and argues for the dependency among them. It explains why strong technical resources in engineering-oriented universities coexist with weak links between courses. And it proposes a pathway that applies whole-task design across courses, built for conditions in which technical modules are shared across programs and the economics program cannot rework them.

2. Components of Digital Literacy in Economics

Digital literacy grew out of information literacy. Information literacy concerns finding, evaluating, and using information; digital literacy has been read as its extension to big-data environments, with more emphasis on practical digital skills^[9]. Major international frameworks cover three areas: understanding and evaluating information, practical application, and ethical responsibility^[4]. The term has no single settled definition, and its meaning shifts with context^[10]. In this paper, digital literacy in economics means the ability to obtain, process, and evaluate economic information and data in digital environments, to use digital tools to analyze economic problems, and to observe the relevant ethical and security requirements. It has three levels.

2.1 General Literacy

General literacy does not depend on disciplinary knowledge. It includes an understanding of digital technologies and the value of data, the ability to search for and evaluate information, and awareness of personal data protection, cybersecurity, and appropriate data use. When analyzing a problem with digital resources, a student first has to find reliable data, check where they come from, and understand the statistical definitions and measurement conventions behind them. A student with good economic theory can still go wrong at this step by choosing unsuitable data or misreading them.

2.2 Professional Literacy

Professional literacy is the discipline-specific level. Its core is the ability to recognize what economic data signify and to judge them with economic knowledge. General literacy asks whether data are reliable; professional literacy asks what economic phenomena the data represent, what they mean, and how they relate to theory and to the real economy. Students need basic concepts and theories, and they also need to interpret indicators, notice changes in them, and decide which changes deserve further analysis. Given data on household income, consumption, and employment, for example, a student should know what each indicator measures and what its movements might indicate under theories of income distribution, consumption, or the labor market.

2.3 Integrated Application Literacy

Integrated application literacy is the ability to use digital technologies to analyze economic data and address real economic problems. Around one problem, students combine economic knowledge, professional judgment, real data, and digital tools. They clarify the economic meaning of the problem, identify the data needed, choose tools and methods, obtain results through data processing, modeling, or visualization, interpret the results in light of economic theory, and draw possible responses. In analyzing changes in household consumption, for example, a student should do more than describe the composition and trend of the data. The student identifies a question the data raise, selects relevant factors on the basis of economic knowledge, collects and organizes the data with suitable tools, and examines possible explanations for the change.

The level also requires judgment about the results. Digital analysis raises the efficiency of data work, but its outputs are not economic conclusions by themselves. Students must assess whether the data suit the question, whether the method fits the problem, and whether the result has a plausible economic reading. They must also recognize the limits that come from data quality, model specification, and the method used.

2.4 The Interdependence of the Three Levels

The levels differ in scope and in what each presupposes. Professional literacy presupposes general literacy: an economic reading of an indicator is only as good as the student's grasp of what it measures, where it comes from, and how it is defined. A student who does not know how an unemployment rate is defined cannot say what a change in it means, however much labor-market theory the student has learned. Integrated application literacy presupposes both. A student can fit a regression to two series without knowing whether the relationship is one the theory would predict, and then has no way to tell a sensible estimate from an artifact. Choosing variables, choosing a method, and reading a result all require an economic understanding of what the data stand for, and the data must be reliable to begin with. In the terms of complex learning, general and professional literacy are constituent skills, and integrated application is their coordination on a whole task^[8]. The dependency concerns what a student must be able to do, not the order of teaching. Coordination is not acquired by mastering each constituent separately and adding them up, so the pathway in Section 4 develops all three levels through the same tasks.

3. The Curriculum Context and Its Difficulties

3.1 Program Orientation

Economics programs in engineering-oriented universities sit among strong engineering disciplines such as computer science, automation, industrial engineering, and management science and engineering. The laboratories and software platforms of these disciplines are open to economics students, and the programs draw on them to build quantitative and digital skills into economics education. Academic evaluation in these universities favors work that solves concrete problems, and economics students can join enterprise-commissioned projects and engineering-oriented competitions.

The curriculum falls into three groups. The first is mathematics and digital technology courses: mathematical analysis, algebra, probability and mathematical statistics, programming, database principles, operations research, systems engineering, and statistical software. Many of these are common modules that the university offers to several programs. The second group consists of economics courses tied to industry and technology, such as technological economics, engineering economics, and innovation economics. The third is the core economics courses: microeconomics, macroeconomics, political economy, and econometrics. The first group gives students tools for quantitative work, the second connects economics to industrial and technological practice, and the third supplies theory, disciplinary knowledge, and analytical methods.

3.2 Effects of the Orientation

These strengths are spread across separate modules that follow different knowledge structures.

Courses in mathematics and digital technology are organized around the knowledge of mathematics, statistics, or computer science. Students meet programming, databases, and statistical software early and have many chances to obtain and process data on digital platforms, which gives general literacy a solid footing and supplies the technical skill that quantitative economic work needs. The limit is what these courses ask of students. They learn how to obtain data, write programs, and run models, and they seldom have to ask why a method suits an economic question, how to choose among methods, or what the output says about the question. Proficiency with tools can grow without the ability to use them for judgments about economic data.

The core economics courses give students the knowledge needed to understand markets, economic behavior, and economic phenomena, but they often rely on theoretical models, conceptual analysis, and established cases, and real data and digital tools may play a small part. Meanwhile the program must fit in many quantitative, computing, and industry-application courses, and some curricula include courses such as computer hardware or mechanical engineering. Teaching time for the core economics courses, especially for practical and experimental work, shrinks. Students may know the theory yet be unable to turn it into an empirical question, choose a tool, or interpret a result.

No course asks students to use both kinds of knowledge in one task, so integrated application literacy has nowhere to develop. Consider whether rising housing prices have crowded out household consumption. The student must first use consumption theory to say how housing wealth, income, and housing expenditure could affect consumption. Python then serves to collect city-level data from public sources such as the National Bureau of Statistics of China and to match them by city and year, and Stata to estimate a panel model with robustness checks. A significant negative coefficient would still not settle the matter. Housing prices and consumption both respond to income expectations and credit conditions, and causation may run in either direction, so the student must ask whether the design supports a causal reading, with what controls and what source of variation in prices, before interpreting the result through the housing wealth and crowding-out mechanisms and drawing cautious policy implications. Every step draws on a

different course: theory, programming, econometrics. Where the courses are taught separately, a student can pass each of them without ever completing the whole chain for one problem.

3.3 Underlying Causes

Three causes operate at the level of understanding, curriculum design, and teaching organization, and each reflects conditions common in engineering-oriented universities.

The first issue lies in how digital ability is understood. Engineering training judges work by whether a program runs, a model can be estimated, or a system functions. Digital ability is then easily taken to mean producing an output with a tool, and evaluation habits reinforce the reading: a working output is the visible sign that a problem has been solved. Economic research does not end with computation, because the results have to be interpreted to understand an economic problem. Students who approach digital technology through a tool-to-result logic can run a program without knowing why the method was chosen or what the result means.

This gap in understanding affects curriculum design. Mathematics, statistics, and computing courses are typically set by the university as common modules, according to engineering requirements, and their content and examples are generic or drawn from engineering. Economics students take them, but the economics program can hardly adapt what they contain to economic questions. The economics courses, for their part, each keep their own objectives. Each course in the chain may be sound, yet none is asked to hand a finished intermediate product to the next, and nothing in the curriculum is a stage for bringing the pieces together. The housing-price example shows the result: each course meets its own objectives, and the chain from hypothesis to economic judgment is never completed.

The third issue concerns teaching organization. Integrated application is the explicit objective of no course, so it becomes something everyone touches and no one owns. Technical courses are taught by computing or engineering instructors and economics courses by economists, each working to their own objectives and assessments. Economics programs in these universities are small, and their faculty often work in technological or engineering economics, so few instructors can cover frontier economic methods, programming, and data science alone. Practical training does not fill the gap. Competitions and research projects are usually led by engineering disciplines, and economics students often take supporting roles such as business analysis or market research. Only a minority take part on a sustained basis, and unless such work enters the regular curriculum, integrated application literacy remains an extra skill of a few students.

4. Development Pathway

The pathway starts from integrated application literacy and works backward to the other two levels. It has three steps, and each answers one of the causes identified in Section 3.3: redefine what counts as digital literacy, link courses through common problems, and place the resulting tasks in regular teaching.

4.1 Reframing Assessment Standards

The first step is to say what each level looks like in performance. Table 1 states the standards in terms of the evidence a student could produce in the housing-price task.

Table 1. Observable standards for the three levels

Level	Observable Performance	Evidence in the Housing–Price Task
General	Checks the source, definition, and coverage of the data used; states their limits; follows data protection and security rules	A data note on the price and consumption series, with definitions and coverage
Professional	Interprets indicators and their changes with economic theory; identifies which changes deserve analysis	An account of what movements in prices and consumption may signal under consumption theory
Integrated	Carries a question from hypothesis to judgment; explains why the data and method fit; states what limits the result	A reproducible report with hypothesis, discussion of identification, interpretation, and limits

The same standard can serve in course syllabi, assignments, and thesis assessment. Each course can then state which level it contributes to and what evidence it collects, instead of setting goals of its own.

Assessment looks beyond whether the code runs and the estimates are correct. It asks whether the data fit the question, whether the method fits the problem, and whether the interpretation is justified. Engineering programs already value results that can be verified, and that habit can be put to use. Reproducibility, meaning documented data sources, processing steps, and model specification that others can repeat, becomes the entry requirement, and the weight of grading falls on economic interpretation and on the judgment of whether the method fits. A correct regression that nobody has interpreted earns little. Where a report has two readers, an economist can judge the interpretation and a technical instructor the reproducibility.

4.2 Building Course Connections

Following the whole–task principle ^[8], the courses are linked through common problems. A suitable problem has a clear economic meaning, a theoretical basis, and public data. Problems can also be drawn from the program’s industry-oriented courses, such as technological, engineering, or innovation economics, which gives economics students a role in questions that engineering colleagues share. Yearbooks published by statistical agencies and open data portals are typical sources. A short library of such problems is enough for a program to rotate them across cohorts. The analysis of each problem is divided into stages, each taken by one course, and the output of one stage becomes the input of the next.

The housing–price question shows how. The economics course formulates the hypothesis from consumption theory. The programming course uses the data of the same problem for collection, cleaning, and matching. The econometrics course estimates the model, examines whether a causal reading is defensible, and interprets the result. A practical course or the undergraduate thesis then assembles the evidence and states the limits. Course content is not rewritten; what changes is the practice material and the destination of the assignments. Because the economics program cannot rework the common modules but can choose the problems their exercises use. Table 2 sets out what each stage hands to the next.

Table 2. Stages of the housing–price task

Stage	Course	Output Handed to the Next Stage
Hypothesis and variables	Economics course	A hypothesis derived from consumption theory, with the variables it implies
Data collection and matching	Programming course	A cleaned city-year dataset with a data note
Estimation and interpretation	Econometrics course	Estimates, a discussion of identification, and an economic reading
Integration	Practical course or thesis	A reproducible report that states limits and policy implications

Tasks are ordered from simple to complex, and support is reduced as students advance. In early years students complete partial tasks, such as checking the source and definition of a dataset. In middle years the tasks add economic interpretation. In the final year students complete the whole task. The same problem can return at higher complexity in different years, and part-task practice such as programming exercises continues alongside the whole tasks. Following the same model, supportive information, such as how to think about identification, is given to the class before the task, while step-level instruction, such as how to merge two datasets in Python, is given when the step arrives.

4.3 Making Integrated Tasks Part of Regular Teaching

The tasks enter required course assignments, course projects, and the undergraduate thesis. In practice, each required course in the chain carries one graded task drawn from the common problem, and the thesis requires a whole task from question to judgment. A program can ask that the thesis topic come from the problem library or from an equivalent problem, so that every graduate completes at least one whole task. Competitions and research projects remain useful extensions, but they are no longer the only place where integration happens, and students outside them receive the same training. A program can start with one common problem in one cohort, review the student work at the end of the year, and extend the design in light of what it shows.

Program revision supports this. When credits are reallocated, hours for practical and experimental work in the core economics courses should be protected, since these are the hours squeezed by the modules described in Section 3.2. Duplicated tool exercises can give way to the common problems, so that no new tool courses are needed.

5. Supporting Mechanisms

The pathway needs people and routines to carry it. Four mechanisms follow from the diagnosis in Section 3.

5.1 Coordination Responsibilities

Cross-course tasks need an owner. Depending on program size, a course group or a single coordinator can hold that role. The coordinator maintains the common problems and their data, agrees with each course on the output it hands on, adjusts later tasks in light of earlier student work, and answers for integrated application literacy in the program. This fills the gap described in Section 3.3, where the outcome belongs to no course. The coordinator has authority over the problem library, not over the content of individual courses. In a small program the role can be filled by one economist working with a colleague from computing.

5.2 Faculty Collaboration

Instructors plan jointly before each term. Economists specify the economic question each technical exercise has to serve, and technical instructors show how data work and methods support the analysis. Together they set outcomes and assessment for each stage. Shared task sheets, data files, and worked examples spare a small program from expecting every instructor to master economics, programming, and data science, since the technical expertise already exists elsewhere on campus.

5.3 Student Roles

In engineering-led projects, economics students often work as supporting analysts. In cross-course tasks the economics student takes the economic side: stating why the problem is worth studying, what data it needs, why a method fits, and what the results mean. As students advance, instructors reduce support for technical operations, and students move from following a procedure to designing the analysis. Individual grading on the economic side of team tasks keeps this role visible.

5.4 Curriculum Revision

New data sources, tools, and economic problems appear faster than fixed course content can absorb them. The program revises its tasks regularly, using the gaps visible in cross-course assignments, practical training, and theses. The review can follow each year's thesis defense, when the whole chain is visible. A revision may adjust a task, add a linking activity, or replace a common problem and its data.

6. Conclusion

This paper distinguished three levels of digital literacy in economics and argued that each depends on the one below it. In engineering-oriented universities, strong technical resources sit in common modules that the economics program can hardly adapt, and no part of the teaching organization is responsible for connecting them to economic problems. The pathway responds with performance-based standards, common problems that link courses as whole tasks, and regular teaching in which every student meets those tasks. Coordination responsibility, faculty collaboration, student roles, and curriculum revision support it.

The pathway rests on three conditions: public data that can support common problems, technical instructors willing to design exercises around economic questions, and room in the program to change the material of assignments even where the modules are fixed. It does not replace the strengthening of core economics courses. It makes the tools already in the curriculum count toward economic analysis. For program planners, the first decision is who owns the link between the courses already offered; adding a technical course comes later, if at all. The study is conceptual, and its claims about engineering-oriented universities rest on argument rather than data. Common modules and program size differ across universities, so the causes in Section 3.3 will apply unevenly. Later work can examine the pathway through case studies of programs in different engineering-oriented universities, using course documents and student work, and can assess its effects on students' digital literacy.

Funding

This research was funded by the Hebei Provincial Science and Technology Plan Soft Science Special Project (grant No.22557622D) and the Doctoral Research Start-up Fund of North China Institute of Aerospace Engineering (grant No. BKY-2018-28).

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