JUST-IN-TIME EDUCATION: AN IDEA WHOSE TIME IS OVERDUE

Thomas Hulbert, Eric Hansberry, Robert Angus
Northeastern University; Boston, Mass.

The United States is in an increasingly competitive international market. The demand for well educated scientists, engineers, and engineering technologists is growing. Many students at both the secondary and collegiate levels are poorly prepared to enter the workplace. Educators and business leaders recognize the need for extensive revamping of science, technology, and engineering curricula at associate-degree granting institutions to meet the needs of business, industry, and government.

The Just-In-Time (JIT) educational concept is designed to provide technical education on an as-needed basis, meeting the requirements of students and employers. JIT uniquely combines education's behavioral objectives with technical curricula by integrating (1) basic core concepts, (2) the manufacturing line-balancing technique and (3) occupation-driven-based problems. This paper provides a description of the development of the JIT education model and a demonstration of the JIT concept using linear equations as applied by engineering technology students.

The Just-In-Time Concept

The Just-In-Time concept refers to coordinated learning and involves a set of core engineering technology topical outcomes from math, physics, English communications, and engineering economics. The topics are integrated into a network of focal points or nodes formatted via behavioral objectives. The outcomes will be documented in a flexible manner so knowledge can be taught to individual students on an as-needed basis. Students better understand and retain a specific algebra topic when that topic is immediately applied in another course such as physics. The physics material is reinforced when immediately applied to a mechanics, circuit theory, or other technical example. The totality is reinforced when students are required to document their results in writing.

The JIT approach will improve the coordination and integration of existing modules, courses, and programs. JIT education will utilize computers and multimedia material-preparation equipment presently available to many educational institutions. JIT materials can be accessed via hard-copy by those educational institutions that do not have more sophisticated computers. Institutions may customize JIT to fit their local needs. JIT outcomes will be models rather than specifications so educational institutions can prepare custom modules, courses, and programs. The JIT approach is to

- improve teaching productivity via curricula streamlining thus reducing unnecessary faculty effort,
- empower students so they will feel more in control of their education, and
- improve economic, communication, and technical relevance.

The JIT curricula development includes:

- Write behavioral objectives for the demonstration network.
- Prepare a script for multimedia development.
- Devise a multimedia sequence with flexible node-test questions.
- Prepare multimedia material where applicable.
- Test the multimedia material on a control group of students.
- Compare the control group with a group taught traditionally.

Later development will include

(a) hard-copy JIT material interaction and

(b) a sample multimedia presentation.

Software will be developed that monitors the time required for each student to achieve the educational behavioral objectives. Difficulties encountered by students in achieving the required knowledge will necessitate further investigation to determine the required additional supportive material.

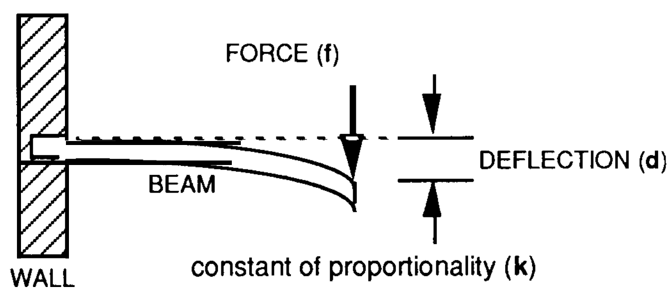
The participating students will document knowledge in two ways:

- A written report will describe how the knowledge was acquired.
- Node tests will evaluate student ability to absorb and apply new knowledge.

A JIT Mechanical Engineering Technology Example

The demonstration mathematics concept is to learn and to apply the algebraic equation: $x = yz$. The students will learn to substitute numbers for letters. Next, students will learn to solve the equation for one of the letters, such as y, in terms of x and z.

Students are then given a physics example – a fully fixed cantilever beam. The physics relates the force **f** applied to the end of the beam to the distance **d** the beam deflects. Students will be taught that the beam deflection **d** is proportional to the magnitude of the force and the modulus of elasticity **k** of the beam. The equation becomes **f = kd**. In the terminology of math and physics, **k** is the constant of proportionality, known as the modulus of elasticity.



While learning the theory, students proceed to a physics, materials, or mechanics laboratory to perform a beam-deflection experiment. Students will learn that a product using this principle is the weight-measuring scale.

Students will select the type and size of material from available handbook data and design a scale whose range is from zero to ten kilograms (22 pounds). They will be instructed to attach a pointer and to calibrate the pointer to read in kilograms and pounds.

The focus of this example is: “Apply linear equations in one variable to a physics beam-deflection problem.” One node-test problem is: A metal beam deflects 4 cm when a force of 20 newtons is applied. Detemine the beam’s modulus of elasticity. (The integers chosen for this test can be varied automatically in a computer-controlled presentation.)

The economic-analysis portion of this problem may require the students to visit local supply houses or refer to catalogs to determine the cost of weight-measuring scales. Students will estimate the production costs for the designed scale. (Later cost-analysis topics will include the effects of scale precision upon shipping, handling, and marketing either for the scale or a more sophisticated device.)

The technical-English writing for this node will require the students to prepare a description of the scale, including the scientific, mathematical, and engineering principles involved. Students will also write a nontechnical, sales-oriented description.

A JIT Electrical Engineering Technology Example

A companion demonstration topic for electrical engineering technology students utilizes Ohm’s Law, e = Ri. This is a linear equation in one variable. (For learning purposes, its behavior will be compared to the beam-deflection example by the students.)

There are nodes designed to teach mathematics, physics, technology, economics, and English. The English node is given below with its subnodes because it summarizes the information contained in the other four nodes.

English Node:

Subnode 1 Given the concepts of voltage, resistance, and current, the student will

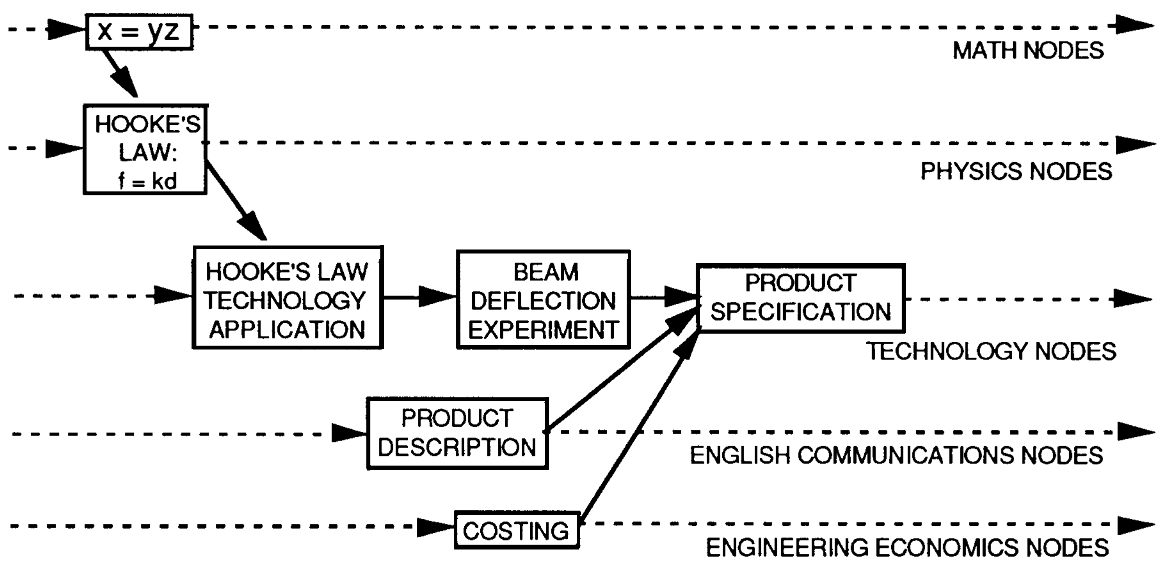
- (a) describe the effect of each parameter interacting with the other parameters, utilizing the words “varies”, “directly”, and “inversely”,
- (b) reconcile the discrepancies between the mathematical presentation of Ohm’s Law, and the concepts of a short circuit and an open circuit,
- (c) expound upon the concept of “free” electrons as electric-energy carriers,
- (d) describe the communication efficiencies based upon observing ordered pairs displayed on a two-dimensional graph,
- (e) discuss the usefulness of the word “continuous” when connecting in a straight line a number of ordered pairs,
- (f) discuss the differences between the percent errors for each of the corresponding values of current, and the possible reasons for these differences,
- (g) explain in writing the difference between reading the description both without accompanying diagrams and with accompanying diagrams — see English 1(d), and
- (h) discuss the cost of improving the resistor precision from 20% to 1% — see Economics 1(a) and 2(a).

The Conceptual Charts

The Just-In-Time flow diagrams are known as the Conceptual Charts (CCS). These charts are analytical tools used to revise and coordinate the JIT structure. Each CC is a flow diagram of key topics for a given related subject. Nodes are clustered into a network diagram and analyzed using production line-balancing techniques.Learning times can be grouped into modules or courses. Thus lines that connect nodes are constraints. The time to master a node is the time required to achieve the objective.

These charts present the curricula as a smooth continuum of five parallel subjects as noted on the diagram. The beam and scale example, and the Ohm's Law and resistor example each represent one node family within a given CC.

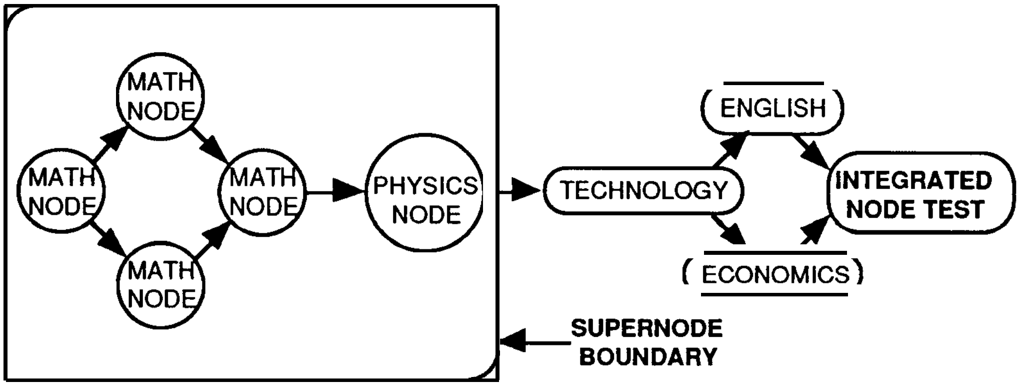
The nodes are defined in behavioral terms to permit the measurement of student achievement. The student must demonstrate proficiency for a given node before progressing to the next node. The student may proceed to the appropriate post-requisite node(s) once the requisite node tests have been successfully completed.



Nodes are grouped into supernodes, based upon

- the level of mathematics required,
- the level of related physics and technology retained,
- the degree of difficulty for students to perform hands-on work,
- the level of English for students to write clearly and concisely, and
- the expected results of node and supernode tests.

The need to review previous material will become apparent. The student will know whereto go to review material or to learn it for the first time. No educational gaps will occur, thus increasing student progress and building student confidence.



Conclusions

The JIT concept integrates the subject boundaries of math, physics, technology, technical English, and engineering economics. At the end of each node or subnode, the change in student knowledge, skills, and attitudes can be tested. The JIT nodes become prerequisites for subsequent nodes. Alternative examples and comprehensive tests will be utilized to place students appropriately within the CC, and will verify that placement.

A seamless sequence is projected utilizing objectives from the eleventh-grade experience through the college Associates Degree level. This seamless approach can be extended in either direction, leading to effective and efficient upward mobility, including the rapid recovery of persons out-of-work.

The JIT approach stresses nation-wide application utilizing measurable evaluation, and curricula flexibility. JIT Education integrates Total Quality Management with outcomes integrated via self-paced instruction. The JIT educational material is offered on time and on demand to students. Funds are being solicited from educational institutions, government agencies, and corporate and national foundations to further develop the JIT model. Just-In-Time education is vital to the future of the United States workforce and the associated economy. It is a student-based learning approach that is long overdue.

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THOMAS E. HULBERT is Professor Emeritus at Northeastern University. He was Director of the School of Engineering Technology for 12 years. He has also served as a faculty member in the Industrial Engineering Department and Assistant, Associate, and Acting Dean of the College of Engineering. He has been a key participant in the JIT concept over the last six years and has authored several papers.

ERIC W. HANSBERRY is Associate Professor of Design Graphics in the School of Engineering Technology. He has extensive teaching and industrial experience. His Bachelor and Masters Degrees are in Civil Engineering. He has authored several papers and has been a member of the JIT team since its inception. He is a Registered Professional Engineer (Mass.).

ROBERT B. ANGUS has a Bachelor Degree in Electrical Engineering and a Masters Degree in Engineering Science. He has over fifty years of industrial, teaching, and management experience. He has authored several papers and six textbooks. He initiated the JIT concept and has worked on the project since its inception. He is a Registered Professional Engineer (Mass.).