Paper No: 253

Customize GIS Education with SCM Model

Matthew Yen

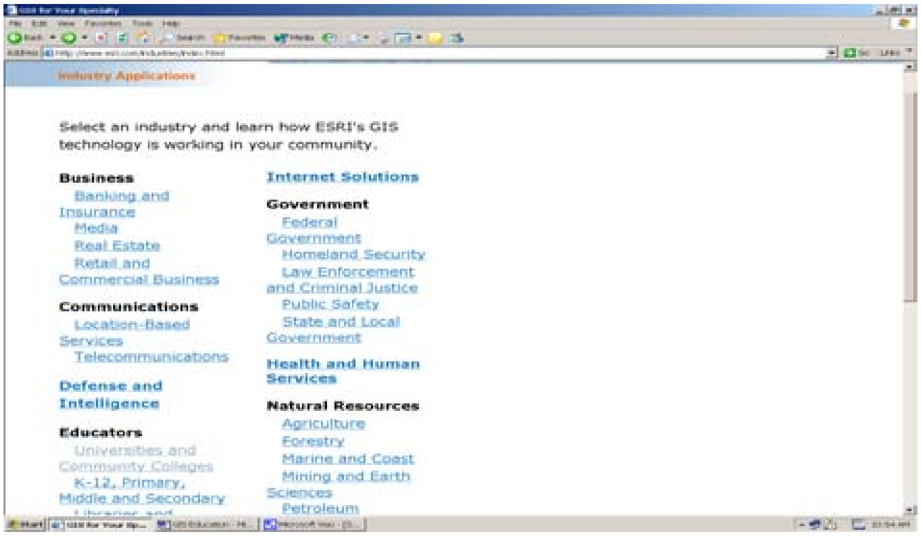
Abstract

The phenomenal applications of GIS present a challenge for the traditional higher education system. Since a ‘one-size-fits-all’ education model is impractical, there is an urgent need to re-think education models for meaningful interdisciplinary education. Historically, applying business models in education systems has been a common practice. Recent technology advancement has created a shift of paradigm in servicing business markets from a mass production model to a mass customization model. Businesses delivers it based on the Supply Chain Management (SCM) model. SCM model may also be applied in GIS education as a framework for interdisciplinary programs, such as GIS education. This paper discusses a conceptual education model based SCM principles.

I. Introduction

GIS education issues

Geographical Information System (GIS) is a dynamic field which increasingly finds applications in a large number of disciplines. Though the cost of GIS technology have been more affordable, curriculum ownership, GIS software and hardware resources controls and management remain debatable issues in higher education. Some universities have offered a GIS major; others chose to provide a service program in a designated department. Nonetheless, after a quick examination of the industry applications of ESRI website (See Figure 1), it is not difficult to see the challenge of designing a curriculum for a GIS program. In a UCGIS education whitepaper, it states: “…Education in the area of geographic information systems is a complicated proposition. Not only are geographic information systems used in a vast array of applications but knowledge about the technology is available from a broad assortment of educators that includes universities, community colleges and GIS vendors…Geographic information science topics are addressed throughout a broad range of academic programs. With the rapid proliferation of geographic information systems in the late nineties, the education of GIS practitioners is not a trivial matter.” [Obermeyer et. al. 1997]



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- Mining and Earth Sciences
- Petroleum

Figure 1 GIS Industry Applications (Source: ESRI website. http://www.esri.com/industries/index.html)

Such challenge demands us to take a 'fresh look' of our education system. It is important to identify underlying assumptions which were made in the past and to expose inherent constraints in the system. We can then exploit constraints to formulate strategies and plans for GIS education.

A Historical Perspective

Management principles and concepts in the business world had profound influences in American higher education system in the past. For example, at the turn of the last century, U.S. higher education had adapted Frederic Taylor's scientific management principles: departments were formed according to the principle of divide-and-conquer; classes were scheduled in periods based on the principle of time-motion studies; units are assigned to courses with hourly wages calculated accordingly; schools and public education systems were created to pool resources to eliminate waste and redundancies; etc. Knowledge is divided and subdivided so that it may be delivered in an education system similar to the mass-production system of Ford Motors Company. Later as businesses have merged and consolidated, schools and universities followed steps as well by developing comprehensive school districts and giant university campuses [Reich, 1983]. Many administrators do in effect take the view that a school system is a 'production system'. Production concepts and management practices are often applied in education system. 'Efficiency' became the underpinning goal for many education administrators.

The appropriateness of this point of view has been debated in the past and it is still a controversy today. It is not the intent of this paper to debate the above point of view. Rather, this paper examines two fundamental education models based in production systems in relation to GIS education. Prior to the exposition of the two education models, stories of two students are presented below as a preamble:

Two Cases

Tim is a student at a four-year university. Tim's father is a philosophy professor in a university. Tim grew up in a culture-diverse environment. He has very rich intellectual interests. However, he has vague ideas about what to do in his life. During college years, he bounced across several majors: philosophy, psychology, computer science, electrical engineering, information systems, industrial technology, etc. After nearly ten years of soul searching, he finally graduated from the department of sociology with a GIS emphasis. He loves GIS technology and the broad range of applications and would like to major in it. However, the university which he attends does not offer a GIS major. There is a proposal for a GIS major which is in the pipeline for approvals. But, it is at least two years away from the year he graduates should it move smoothly every step along the pipeline. Tim's graduation is already long overdue and he has to move on.

Chris is a graduate student who has recently engaged in a research project in crop management with a faculty. In the course of working on the project, Chris has found that GIS as an invaluable tool for information management and communications with others. He does not have room for a GIS course in his 'crowded' curriculum. The best he can do is to learn on his own via books, tutorials and virtual campus to gain the necessary skills. Since Chris is a graduate student, he is more interested in applying GIS technology instead of getting additional credentials. However, getting GIS training and education proves to be a challenge: a. he has limited time for training courses; b. he has limited access for a well configured system to practice the GIS software. Learning GIS by working on a project is an ideal situation, but, Chris has only a year to work on the project while completing required courses. Chris needs helps to climb such a steep learning curve to apply GIS for the project.

In the first case, Tim had no specific needs for GIS training and education. He enjoys learning GIS as an intellectual interest. While in the case of Chris, he had a specific need of GIS training for his project. However, in both cases higher education systems failed to provide timely GIS education and/or training. The underlying problem is that higher education is structured and administered in a 'mass-production' mode. Unless there are evidences for a 'critical mass' courses and curriculum will not be offered. As alluded earlier, such 'mass-production' thinking has its origin in production systems in the business world. It is interesting to take a look how production systems have transformed in today's business world.

II. Paradigm Shift in a Network Economy

As it were inspired by the Olympic Games' motto: ***citius, altius, fortius (faster, higher, stronger),*** today's global business environment demands manufacturers and companies to deliver fast, and to service a large number of customers with improved quality. Manufacturers adapted various production systems, such as: Just-In-Time, lean manufacturing, agile manufacturing, etc. [Schoenberger 1988 and Liker 1998]. Federal Express, UPS (Untied Parcel Services), intranet, extranet, Concord jets, etc. are just a few icons of modern day business landscape. People, goods, funds, etc. are all moving at unprecedented fast pace. Such fast tempo has caused a paradigm shift of business strategies: *Manufacturers are moving away from* ***push- production systems*** *for* ***mass production*** *to* ***pull-production systems*** *for* ***mass customizations***. Instead of producing large quantities of a few models based on sales forecast, manufacturers build to customer's specifications. Parts are not ordered until there is an order. Reddy refers it as a shift from forecast based market economy to customization based network economy [Reddy 2001].

Behind lean manufacturing and pull-production systems is the supply chain management (SCM) system. A well known SCM implementation example is the Dell Computer Corporation. Dell sells computers to its customers directly through phones and internet. Dell manufactures its computer systems at six locations: Austin, Texas; Nashville, Tennessee; Eldorado do Sul, Brazil (Americas); Limerick, Ireland (Europe, Middle East and Africa); Penang, Malaysia (Asia-Pacific and Japan) and Xiamen, China (China). It builds computers according to customer orders without inventory and retail stores. Such practice reduces or eliminates inventories for both raw materials and finish goods. It frees up capitals and improves products quality. It also resulted in greater customer satisfaction. Furthermore, it allows Dell the flexibility to adapt new technologies [Yen 2002].

Figure 2 is a schematic of a typical supply chain management system. A company serves as a channel master to provide a value-added process. The output can be products only, services only or both. The value-added processes can be activities common in industry or unique to the company dependent on the products or services rendered. [Reddy, 2001]

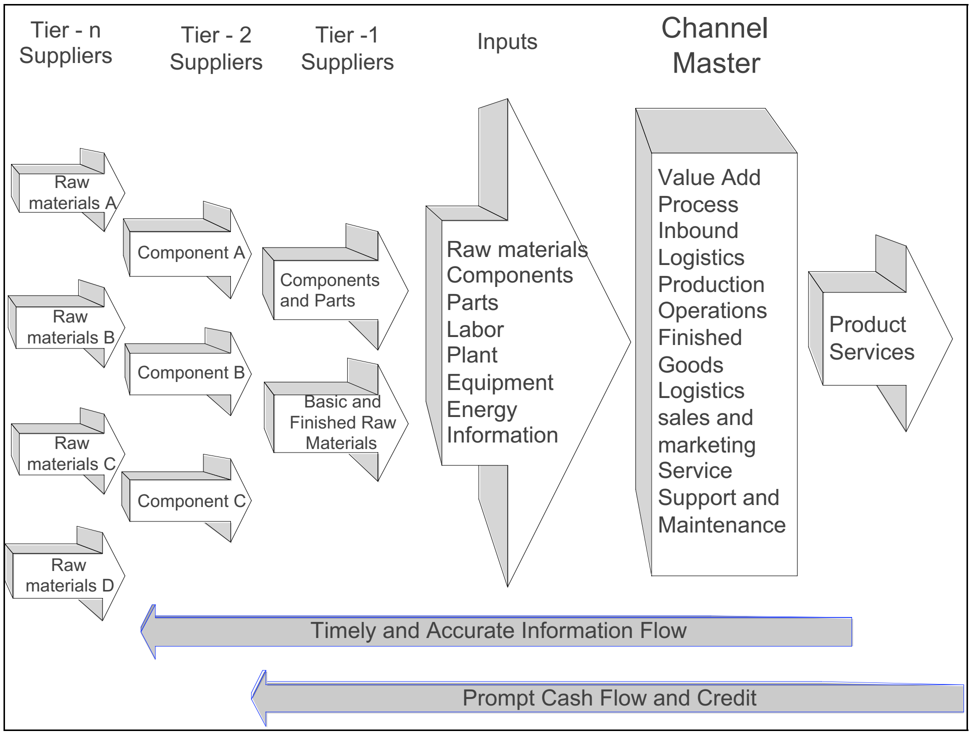

Figure 2 A typical supply chains for a firm producing goods and services.
Adapted from [Reddy 2001]

A typical company procures a wide range of products or services as ‘inputs’ and then transforms them into its own products or services. The inputs may include: raw materials, components, labor, energy, information, etc. The inputs are provided directly or indirectly to a large number of suppliers which may be classified into a number of tiers. Tier-1 suppliers are business alliances with long term trading relationships. Tiers of higher order are trading partners which may be called upon to provide products or services dependent on products/services of the time or customers’ needs.

What is significant for the SCM today is that the physical materials can be quickly located, assembled and moved through this chain in spite of geographical locations. Such an efficient channel of material flows is enabled due to firstly the ‘strategically configured’ supply chain; secondly, the rapid and accurate information flow collected and distributed by the channel master. This information flow moves through the supply chain opposite to the material flows. It is interesting to note that the fast moving materials flows also speed up cash flow in the reverse direction. The implication is that trading partners are compensated promptly for their services.

Another benefit of the SCM is that quality is preserved because of accurate specifications are conveyed to trading partners at the early stages of the material flows.

III. SCM as a Concept Model for Customized GIS Education

Customize GIS education is an idea advocated by many GIS educators. Following is a quote from the UCGIS Education Policy White Paper [Miller et. al. 1997]:

> By maintaining a "one-size-fits-all" education model, GIScience runs the risk of being considered irrelevant by practitioners. The subsequent misuse of GIS/GIA techniques would ultimately damage the credibility of this technology for addressing society's problems. Tailoring GIScience education to diverse professions will increase the likelihood that GIS will be deployed properly and effectively.

The UCGIS Education Policy Whitepaper suggested the following classification according to the educational market segments: *managers, application-oriented GIS users, GIS analysts, GIS developers, GIS technicians, educators*. The diverse needs in GIS education market are not much different from the needs for various computer configurations in DELL Computer's case. Concepts, principles, and management techniques of planning and designing a service chain management system may be found useful.

As described previously, higher education has long been fashioned as a 'push-production system'. In a push production system implementation, goods are manufactured according to a market forecast quantity which is based on the past sales record. Similarly, higher education institutions often allocate resources based on historical records, or, known as a formula-driven budget. In the past decade university administration is taking more of a distributed governance role [Haak, 2000]. Coordination amongst departments and units are increasingly difficult. Since GIS applications span across a wide range of disciplines, formula-driven budget will inadvertently impede the development of GIS curriculum. Administrators and educators must come to realize the paradigm shift for a pull-education system other than a push-education system. Otherwise, providing customized GIS education will be a constant struggle.

GIS education can be delivered either as a general education curriculum (push system) or as a vocational/professional curriculum (pull system). Figure 3 shows a spectrum of student population may be reached by both systems based on the concept of 'range and reach'. "Reach and range are critical concepts in the context of selecting various supply chain or web technologies. Peter G.W. Keen introduced these terms in the early 1990s, and, despite the ever changing technology integration landscape, they remain relevant." [Reddy 2001, Keen 1991 and Yen 1996]. Here, the concept of reach refers to the population of students it may reach based on the type of education systems. The range refers to the gamut of disciplines in education systems. In a push system it may reach a large number of students through general education courses. On the other hand, certificates, licenses and GIS degrees have a limited reach depending on applications. This figure provides a framework for formulating GIS education strategies.

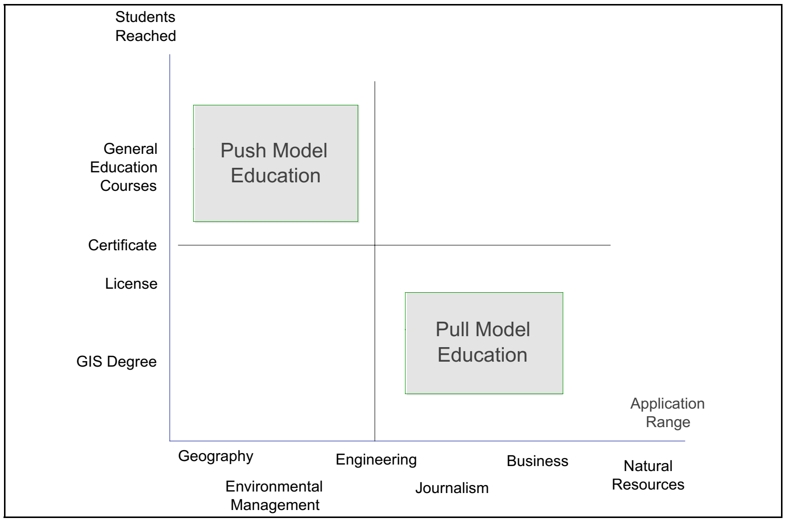

Figure 3 Reach and range of SCM education models.
Adapted from [Keen 1991].

SCM concept can be applied in both push and pull education systems. Figure 4 illustrates the concept of applying SCM for GIS education. Similar to a production system, the supply chain is coordinated by a ‘channel master’. In a push curriculum, the channel master would be the instructor who teaches GIS courses. Instructors may use GIS software provider as the 1st tier supplier or content provider. If an instructor is interested in a particular domain, respective domain GIS users or developers may serve as 2nd tier content provider. In a pull system, the channel master may be a GIS department, a program, or instructors. Students in a pull system may be allowed to plan their own curriculum based on individual needs. Channel master would act as an agent to meet such needs. Special case studies or training materials may be arranged through services of multi-tiered suppliers or content providers. The success of SCM implementation is hinged on a tight communication and articulation between channel master and suppliers of all tiers.

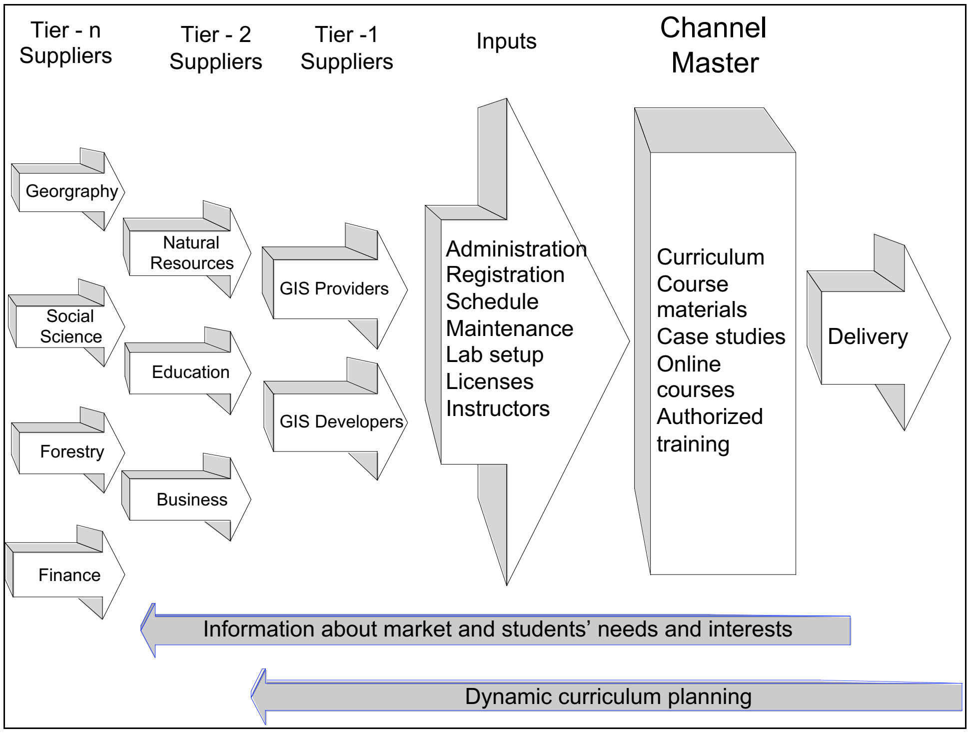

Figure 4 SCM Model for GIS Education.

The advantages of applying SCM concept in GIS education would be similar to those in a service chain. Needs and opportunities for students are quickly identified and planned in education. SCM enables new applications be incorporated in curriculum in a timely manner and reduce the degree of obsolescence. The uses of GIS vendors, developers and application users as content providers would greatly alleviate the stress and strain on faculty development. It also allows faculty to stay current with the technology. The following table summarizes the advantages of SCM in production as well as in education:

SCM in Production	SCM in Education
• Customer configuration of orders, fast response • Delivery to home and business • Cash collection at point of sale • Low components inventory • Rapid response to technology changes • Shorter lead time • Outsourcing • Tiered suppliers and alliances	• React to employment market • Improved technology accessibility • Network of curriculum providers • Strong articulations and communications with experts • Enable continuous faculty development • Shared ownership. Less development costs and maintenance costs • Quality education preserved

Figure 5 depicts the skill levels may be attained with respected to technology accessibility. Accessibility is defined as the availability of hardware, software, instructional materials, knowledgeable instructors as well as user friendliness. In the SCM model, channel master must coordinate with tiered content providers to ensure proper GIS education resources accessible to students. 'Learning by doing' or 'hands-on education' is known as the best approach for students to learn in technology fields. However, administrators and educators must realize that planning and coordination are essential elements for successful hands-on education. Students are easily frustrated and discouraged in hands-on learning especially when they have to wrestle with technology accessibility. In this figure, it also illustrates that GIS education is more effective in a pull system than in a push system. SCM model will undoubtedly improve technology accessibility for either type of education systems.

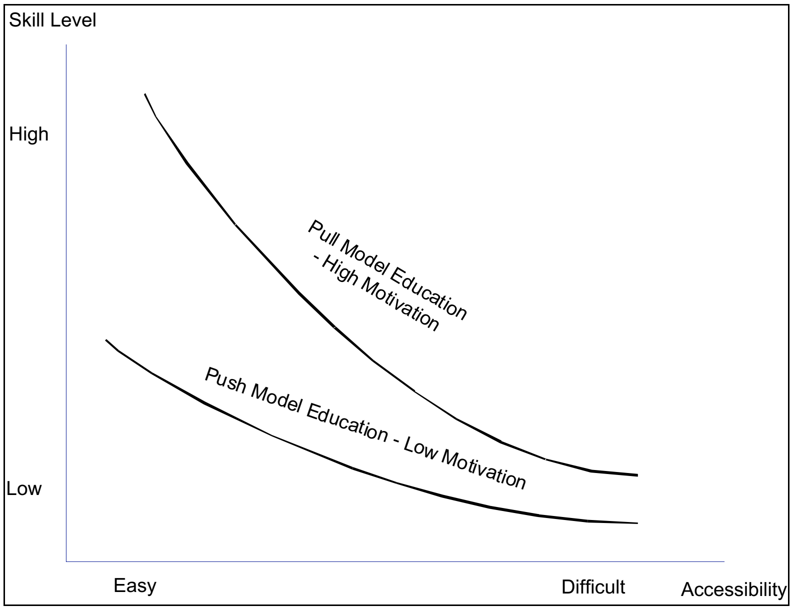

Figure 5 Skill Levels vs. Technology Accessibility

IV. Implementation Strategies

GIS is not the only field which confronts technology education issues with educational establishments. Database and network technologies share similar challenges. From a practical standpoint, SCM model has already been implemented in some areas. For example, CISCO System has established 9800 Network Academies in high schools, technical schools, colleges, universities, and community-based organizations. Their success in making presences in higher education can be qualified as a form of SCM implementation.

Implementation Examples

Following is two examples of education services provided by two industry leaders: ESRI and CISCO. It is interesting to note as to how they are implemented and articulated at various levels in education systems. The table below summarizes key features of the two programs:

Programs	GIS	Network
Products and markets	Map software and tools; Diverse applications in businesses, government agencies, education, etc.	Network equipments; Focused application on networks for business, government, education, etc.
Website	http://campus.esri.com/	http://cisco.netacad.net/public/index.html
Education programs and resources	ESRI Learning Center: self-paced courses, live training seminars, web workshops, instructor-led courses, GIS Day, Virtual campus, ESRI Press, etc.	CISCO Networking Academy. Delivered globally in multiple languages. Multiple learning styles: Web-based, multimedia content; online assessment and evaluation throughout the course; hands-on labs; and instructor training and support.
Professional market	Managers, Application-oriented GIS users, GIS analysts, GIS developers, Educators.	Network administrators, network engineers, network technicians
Education market	K-12, community colleges, universities, graduate schools	High schools, technical colleges, universities
Certificates and degrees	ESRI does not have a program that "certifies" a person's proficiency or competency at this time. Therefore, ESRI does not have the authority to grant "certifications" to individuals or facilities.	Cisco Certified Network Associate (CCNA) and Cisco Certified Network Professional (CCNP) degrees. Cisco Systems trains the Cisco Academy Training Centers (CATCs), the CATCs train Regional Academies and the Regional Academies train the Local Academy Instructors who then educate students.
Program reach	A network of ESRI-authorized instructors teaches ESRI courses in 49 states and U.S. territories. More than 500 Authorized Instructors and Authorized Learning Centers nationwide offer ESRI courses	Networking Academy has spread to more than 145 countries and all 50 U.S. states. Over 260,000 students have enrolled at more than 9800 Academies located in high schools, technical schools, colleges, universities, and community-based organizations.

It should be noted that the Cisco education program has a tiered support system: every Academy has a "parent" Academy. Cisco Systems trains the Cisco Academy Training Centers (CATCs), the CATCs train Regional Academies and the Regional Academies train the Local Academy Instructors who then educate students. ESRI does not have a tiered structure instead it establishes Authorized Learning Centers (ALC). Cisco program issues certificates while “ESRI does not have a program that ‘certifies’ a person's proficiency or competency at this time. ESRI does not have the authority to grant ‘certifications’ to individuals or facilities. The ATP does ‘authorize’ business partners to use ESRI course materials. ATP partners are referred to as ESRI Authorized Instructors who are granted an approval to purchase ESRI course books and teach classes using ESRI-developed course materials.” [ESRI website http://www.esri.com/training/atp/atp.html]

Regardless authorization or certification, by incorporating the SCM model in curriculum design would undoubtedly shorten institutional development time, provide nearly just-in-time technology updates and ensure quality learning with practical hands-on experiences.

Planning with Theory of Constraints

Numerous management and simulation tools have been developed for planning SCM implementation. A widely adapted SCM planning technique is the theory of constraints (TOC). Theory of constraints (TOC) is the basis for management science. It applies the method of physics to solve general problems in a broad range of management issues. It may provide useful concepts and principles for planning and designing SCM.

There are numerous books published on principles and applications of TOC [Goldratt 1990, McMullen 1998]. Following is a brief exposition of the TOC: TOC takes a progressive approach to improve a system. It begins by examining undesired conditions in current reality, call it State A. Then, it proceeds to delineate the desired conditions in the future, or State B. The next step is to focus on the process to transform from State A to State B. This process uses logic trees as tools to visualize and verbalize intermediate states of the transformation. Interested readers may refer to other literatures for details. The focusing steps for this process of transformation can be summarized as in the following:

The Focusing Steps	Brief Descriptions
1. Identify the system's constraints	1. Identify the resources that are the primary obstacles to progress toward the goal
2. Decide how to exploit the system's constraints	2. Decide on a plan for the primary constraint that best supports the system's goal
3. Subordinate everything else to the above decisions	3. Alter or manage the system's policies, processes, and other resources to support the above decisions
4. Elevate the system's constraints; Do not allow inertia to become the system's constraint	4. Add capacity or otherwise change the status of the original resource as dominating primary constraint.
5. When a constraint is broken, return to step one	5. Go back to Step 1, but do not allow previous decisions made in Steps 1 to 4 to become constraints

According to [Fredendall 2001], there are three types of constraints for SCM:

1. Physical or logistical constraints – these are resources within system which have capacity that is equal to or less than the demand placed upon it.

2. Policy constraints – these are decrees or rules from management staff that sets limits on the system performance in that they do not lead directly to achieving the goals and objectives of the system.

3. Paradigm constraints – these are entrenched habits or assumptions of people in the system that things must be done this way because they have always been done this way. Paradigm constraints often lead to policy constraints which may lead to physical constraints.

The following is a table summarizes possible constraints in implementing SCM model for developing GIS curriculum:

Physical Constraints	Policy Constraints	Paradigm Constraints
• Hardware & software availability • Lab accessibility • Viable curriculum • Instructional materials • Instructors development • Students cognitive ability • Students motivation • Quality time	• License contract • Articulation agreement • Fees and registration • Administration costs • Budget and resource allocations • Assessment & evaluation • Certification or degree compliance • Institutional policies	• Domain barriers • Terms and jargons • Technology and resources ownership • Job security • Credit and recognition • Commitments • Alliance relationships

It is evident that there are numerous constraints need to be addressed for successful implementation. Traversing through the supply chains, more constraints can be identified. McMullen [1998] provides excellent examples as how to apply TOC logic trees to exploit constraints for various applications.

V. Discussions and Concluding Remarks

For the two students in the introduction, Tim and Chris, they are at the mercy of education systems. The current system lacks mechanisms for students with special needs to pursue individual goals. Such a situation is particularly true in higher education due to compartmentalized departments and programs. With a large number of interdisciplinary curriculum needs such as GIS, database, web technologies, etc, higher education must address structural issues in order to satisfy such needs. Current higher education infrastructure has deep roots in concepts such as: efficiency and mass production. By applying SCM model, higher education may form alliances with business leaders to provide customized education. The concept of 'outsourcing' education via SCM enables higher education to stay current as well as to maintain flexibility.

Departmental programs may never go away in higher education. However, SCM system may serve as a reference model for interdisciplinary programs. Nevertheless, 'differentiated classroom' has been employed in grade schools for special educations for years [Tomlinson 1999], why not apply a similar concept in higher education as well. SCM model is a structure for such a 'differentiated classroom'. SCM model offers valuable concepts and principles for planning GIS curriculum. 'Channel masters' must be identified and empowered for its implementation.

The concept of 'outsourcing' technology related education is both appealing and challenging for higher education. On one hand, it may relieve institutions from committing precious resources for frequent technology and faculty updating. While on the other hand, it may pose threats for academic freedom and independence. Such dilemma is a result of changes and paradigm shift [Fullan 1991]:

> It is so easy to underestimate the complexities of the change process… Change is difficult because it is riddled with dilemmas, ambivalences, and paradoxes. It combines steps that do not seem to go together: to have a clear vision and be open-

> minded; to take initiative and empower others; to provide support and pressure; to start small and think big; to expect results and be patient and persistent; to have a plan and be flexible; to use top-down and bottom-up strategies; to experience uncertainty and satisfaction.
>
> Michael G. Fullan with Suzanne Stiegelbauer
> The New Meaning of Education Change [1991]

Dilemmas, ambivalences and paradox may never be resolved unless we have clear goals and shared priorities. Nonetheless, SCM is a viable model for outsourcing technology education.

VI. References

Fredendall, Lawrence, D. and Ed Hill, (2001). Basics of Supply Chain Management, The St.
Fullan, M. G. & Stiegelbauer, S. (1991). The new meaning of education change. New York: Teachers College Press.
Goldratt, Eliyahu, M., (1990). Theory of Constraints, North River Press.
Haak, H. H. (2000) Entrepreneurial Management and/or University Governance, The Trilateral Conference on "Resource, Technology and Social Values: Challenges and Opportunities for Asia-Pacific in the 21st century." Seoul, Korea.
Henderson, B. A. and Larco, J. L., (1999), Lean Transformation, Oaklea Press.
Keen, Peter, G.W. (1991). Shaping the Future, Harvard Business School Press, Boston.
Kemp, K. and Goodchild, M. (1991). Developing a Curriculum in GIS: The NCGIA Core Curriculum Project, *Journal of Geography in Higher Education,* 15(2): 121–132.
Liker, J.K (editor, 1998); Becoming Lean, Productivity Press.
Lucie Press/APICS Series on Resource Management.
McMullen, Thomas B. Jr., (1998). Introduction to the theory of constraints management system.
St. Lucie Press/APICS Series on Constraints Management.
Miller, H., Kemp, K., Brown, D. and Fried, J. (1997). Alternative Design for Curriculum Content and Evaluation, UCGIS Education Policy White Paper.
Obermeyer, Nancy, J. and Onsrud, Harlan, J., June (1997). Educational Policy and GIS: Accreditation and Certification.
Reddy, Ram and Reddy, Sabine, (2001). Supply Chains to Virtual Integration, McGraw-Hill.
Reich, R. B. (1983). The Next American Frontier, Penguin Books, New York, New York.
Schonberger, R. J. (1986); World Class Manufacturing, Free Press.
Tomlinson, Carole, A. (1999). The Differentiated Classroom, Association for Supervision and Curriculum Development.
Yen, M (2002); Critical Issues of GIS/RS Applications in Global Economy, Journal of Beijing Union University, Sep. 2002, Vol. 16, No. S1, Sum No. S6 (A), pp. 32-41.
Yen, M. (1996); Harness the CIM (Computer Integrated Manufacturing) 'Whale' - A Common Sense Approach, International Conference on Education in Manufacturing, San Diego.

Websites

www.ncgia.ucsb.edu/other/ucgis/ed_priorities/contents.html
http://dusk.geo.orst.edu/disted/
http://www.esri.com/industries/index.html
http://campus.esri.com/
http://cisco.netacad.net/public/index.html

http://www.ed.gov/offices/OUS/Budget04/04summary/section2e.html#titleIII

Author Information

Matthew Yen, Ph.D., P.E., Professor
Department of Industrial Technology
California State University, Fresno
2255 E. Barstow Ave.
Fresno, CA 93740
Tel. 559-278-4201
Fax 559-278-5081
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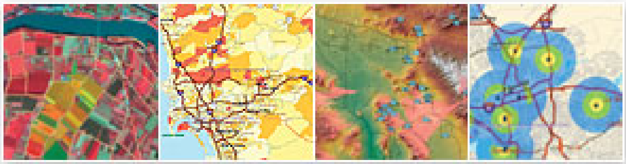

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