Computation Skills

(understanding and applying mathematical concepts and reasoning, analyzing and using numerical data)

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21st Century Learning Outcomes Project
Computations

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Abstract

This anecdotal "white paper" has been provided as a foundation for collegiate discussion on how computations are being used in higher education. Computational skills were determined by an earlier stage of the Twenty-first Century Learning Outcomes project as one of the eight categories of essential core skills necessary for successful preparation of community college students for transition into the continually transforming workplace of the 21st century. It was determined that the "white paper" addressing computational skills would not be written by a mathematician. Instead the paper would be prepared along the line of how computational skills are reinforced and applied on the technical side of the college.

The preparation for writing this paper involved research into the existing 21st Century project and the objectives that project intends to meet. Additional research was undertaken on an informal basis to determine how mathematical computations were being applied across various disciplines.

The informal research conducted pointed to a gap in student preparation for meaningful application of computational skills. This gap does not pertain to any fault of the training received in the math courses at Montgomery College; but rather is a by product of how technical courses are sequenced in relation to the student's successful completion of math courses. Due to this gap in student preparation instructors have privately admitted limiting and/or omitting the amount of mathematical computation required in their course – even if the course content required the mastery of mathematical application. Reasons given varied from "students really only need to understand the theory", "I wish I could focus more on the math, but the students aren't ready; many haven't even started taking their math courses", to "I cover the necessary computations (by teaching the required math), but I downplay most of the computations because it is less stressful for the student…an understanding of the theory at this point will enable them to focus on the computations when they repeat the course at the university level".

Based on the research findings, this paper has been developed along the lines of what must be done (polemical) in order to meet the challenge of preparing our students to apply advanced mathematical concepts and computations in technical courses. The models provided for change have been prepared utilizing the curriculum for the AAS in Management.

Introduction

> ***We must design a new blueprint for education, a plan for the future that specifies what students need to know, when they need to learn it, and what we need to do to help them.***
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> ~ Edward M. Kennedy, 1994

The 21st century brings an era of historic change in which the new communication, computing and information technologies have the potential to renovate education and society. Information and knowledge will decide the fate of both individuals and institutions, and more than ever, an enlightened citizenry will need to be intellectually empowered to provide for the common good. To educate America for the 21st century, we need a strategic vision of change.

> The 21st Century Learning Outcomes Project answers this call while contributing to the larger K-16 education reform movement by helping to build the ***new blueprint for education*** that Senator Kennedy suggests. ….
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> This project is designed to provide the needed set of performance standards assessment models, and best practices for performance-based learning that will help community colleges devise new ways to measure and record student acquisition of learning outcomes for the 21st Century, **thus better preparing community college students for transition into the workforce or transfer to four-year institutions**. …..
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> The long-range vision of this project is to foster the establishment of new standards and documentation for student learning in the first two years of undergraduate education. ….. **The project is aimed at improving student performance by addressing questions of what students need to know and how colleges can demonstrate that students have achieved the appropriate knowledge, skills, and abilities they need to be active, contributory citizens.** … The new approaches to learning certification developed in this project will offer students more personal power over, and responsibility for, their education by giving them accessible, portable information about their learning achievements. …..
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> Combining the expertise and resources of the League with those of colleges committed to developing long-term, institution wide initiatives to become more learning-centered institutions, this project **will contribute replicable models** and a resource network to the more than 1300 American community colleges, as well as to two-year colleges around the globe. ….. (21st Century Learning Outcomes Project).

Educational Requirements of the 21st Century Employees

People will increasingly find that success requires using new forms of information and communication. Hence, an education for the 21st century must provide people with mastery of the intellectual and technical skills necessary to participate to their full potential. Education will increasingly be judged, not only by what the educated know, but also by what they are empowered to do in fulfilling their lives and contributing to the greater social good.

Few educators would argue with the suggestion that a close study of a mathematics course should have an impact on the thinking of students beyond merely grasping the technical how-to of computations. The study of mathematics should help develop the students' critical thinking and decision making abilities and ***should even help them one day to think and act effectively in contexts removed from the original concern of the text.*** **By making such expectations known and by clarifying how to develop cognitive and analytical skills, we assist students in learning how to learn.**

Community college students learn how to apply and practice applying their cognitive and analytical skills as they finish their academic courses and begin to study the courses in their chosen major. A student inadvertently places themselves in a learning disadvantage when he/she enters the courses of their given major prior to completing academic requirements – primarily all required remediation and college level math and English courses. The learning disadvantage occurs because the student does not: (1) have the basic skills required to master the learning outcomes of the given course, and (2) the absence of those basic academic skills (such as math) inhibit advanced conceptual application of the skill within their chosen field. Unfortunately, this occurrence of events affects the majority of students rather than the minority in any given class. This is then compounded by the fact that most instructor's do not have time to stop and teach math skills – placing the instructor in the position of opting for a theory based course as opposed to a practical application of conceptual, analytical, and computational skills.

Present Curriculum Model

In typical colleges, the reigning paradigm of instruction is based on the textbook providing the subject matter that students should master in unison, subject-by-subject, level-by-level, and even college-by-college. Education has been rigid and unoriginal, based on absorption of a "complete" body of knowledge, presented and learnt in an authoritarian environment. In general, the student's only freedom of choice lies in the sequencing of courses around those academic courses that hold a prerequisite or co-requisite (such as English and math). This solitary freedom and "right" is the very undermining of the student's success. Allowing them to choose courses in their academic or technical majors prior to having mastered their basic foundation of skills necessary for successful completion of course learning outcomes.

Proposed Curriculum Model

Learning How to Learn

In the 21st Century, individuals, students, learners, managers, … are faced with an ever-increasing amount of information made readily available by the advances in technology. It is unreasonable to expect that any one individual or grouping of individuals will be able to claim complete knowledge and understanding of this information. Additionally, this information must be accessed, analyzed and acted upon in a timely manner to support informed decision-making. **Therefore, we as educators need to avoid approaches that imply that everyone needs to know the same bank of information or that learners of the same major need to know identical things.**

Subjects are only a minor part of knowledge and declining in importance. Students need another kind of knowledge to be effective in the modern world – the know-how of the researcher and a tool-kit for learner-managed learning**. Knowledge necessary for success in the 21st Century requires that everyone understands how to find out, to learn, relearn and unlearn, and how to manage our own learning on the principles of plan, do and review.** All programs of study leave people with gaps in their knowledge and skills. **Those who have learned how to be taught must wait on someone else to motivate him or her and direct their next learning. Those who have learnt how to learn and how to research can fill the gaps at will.**

Renowned professor and researcher Chris Argyris and Donald Schon developed learning models to help explain effective and ineffective learning relationships. Learning strategies embedded in Model A (Single Loop Learning), are concerned with maximizing personal wins and minimizing personal losses within a given situation—also known as ***zero sum strategy in mathematical game theory***. Model B (Double Loop Learning) presents a learning process by which individuals question the governing variables, underlying causes, and reasoning or beliefs pertinent to the problem/opportunity before taking action. Model B permits learning to occur, generates divergent viewpoints, and fosters acceptance of decisions by others (Kardatzke, 1996).

> …. Learning will need to be accepted as natural and endemic rather than as something which occurs as a result of discrete learning events or through following a curriculum. …. The idea of curriculum as generally understood does not sit well with Model B. **The hierarchical assumption present in a predefined curriculum – basically that it is one person's responsibility to learn what another decides is fit and appropriate to learn – removes the responsibility from the learner both for learning in its broader sense and for evaluating learning** (Lester, 1996, p4).
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> According to Ackoff, **"a curriculum is a solution to a problem which does not exist… because what one learns is not nearly as important as learning how to learn, … "** (Ackoff, 1974, p92).
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> However, **this does not imply an abandonment of information-bases, theories and educational guidance**. It does mean that the maps presented by theories and syllabi are seen as maps, not territories; information is regarded as such, not as knowledge; facts and conclusions are seen as temporary stopping-points, not absolutes; and thinking includes creative, intuitive and lateral thinking as well as logical thinking. **Maps and guidance-structures are necessary to enable connectivity, but they cannot become prisons, the only way of doing things**. … Certain maps may be initially offered as more rigid than others – those which are concerned with safety, equity and legality, for instance – but there is not justification in claiming they are the territory itself an even they must be subject to enquiry and perhaps in time redefinition by the learner. … **The aim is to develop self-managed and self-evaluated learning which integrates theory and practice, and develops a multiple loop where learning is at once purposive, critical and creative, building towards systemic wisdom and congruence** (Lester, 1996, p4).

To ensure this type of learning takes place students must be academically prepared to succeed in the courses compiling the block of study for their major. **Appendix A** presents proposed degree plan flow charts for the Management Associate of Applied Science Degree, Tech Prep with Specializations. These flow charts propose a few primary differences from the curriculum as it appears in the current NHMCCD catalog:

1. ***1.*** that all required remediation in English (Reading & Writing) be completed prior to attempting any college level course. ***College level English courses should be taken immediately after successful completion of any necessary remediation,***
2. that remediation in MATH 0306 (Pre-Algebra Math) and MATH 0308 (Introduction to Algebra) be completed and the student enrolled in MATH 0310 (Intermediate Algebra) prior to attempting any college level work,
3. that developmental course HUMD 0113 (Learning Strategies for Reading and Writing Intensive Courses) be completed in the first semester of study,
4. that developmental course HUMD 0330 (Student Success Course) be completed no later than the second semester of study, and
5. that MATH 1324 (Finite Math) and BUSI 2372 (Business Analysis) be added to the curriculum. ***These courses should be taken immediately after successful completion of any necessary remediation.*** The suggested inclusion of these Math courses is based on needs identified through individual discussion with Advisory Board members.

These changes have been based on the belief that students must be prepared with the necessary foundation skills to succeed in courses of their major – regardless of the concept to be learnt. Many feel the instructor is solely responsible for student success; but this is an unfair burden for an instructor especially when the student lacks the necessary foundation skills. The primary role of an instructor is to create an environment that is appropriate, conducive and supportive of learning. As educators we can increase the level of foundation skills in the classroom by ensuring that the sequencing of classes promotes optimal academic preparation.

Flexible Skill-Based Training Programs

Additionally, the rapid changes in the 21st Century call for educators in technical programs to create a more flexible based curriculum design. Currently the curriculum of most colleges closely reflects that of NHMCCD, wherein all courses in the technical major are 3 to 4 credit hours limiting the degree to a maximum of approximately 14 courses in the program major. Although the course selections are driven by needs assessment and advisory board involvement, these courses generally overlap in material covered causing duplication and waste of precious educational opportunity. The author of this paper envisions redesigning the Management degree plans to include:

1. the course topics presently identified as essential,
2. those topics that could not be addressed under the present curriculum structure due to credit hour restrictions,
3. sequencing and redesigning the courses to eliminate redundancy by focusing and completing one topic at a time. Topics would be sequenced according to developmental considerations with the skills from one class building on the next, culminating in courses that require the successful mastery of skills addressed previously,
4. moving away from dependency on textbook based training, and
5. changing credit hours to more closely reflect the time needed to thoroughly teach the course content.

Appendix B presents an example of how the flow chart for the Management Associate of Applied Science Degree, Tech Prep with Specializations, and Human Resource Specialization, can be changed to encompass these ideals. The flow chart holds constant the changes mentioned in the previous section, with the addition of changes added to semester 6,7, and 8. **Please note** also the inclusion of a new specialization composed of entirely electives in the last three semesters. The new specialization will allow students who do not precisely fit into our "cookie cutter" models of degree specializations to custom design a degree to meet their career needs. This will allow students to meet their educational goals and at the same time increase the number of graduates. Although this subject is worthy of discussion in great detail within the forum of the 21st Century Learning Outcomes Project, it is somewhat outside the boundaries of this paper – so discussion of the topic will be kept to a minimum. The inclusion of Appendix B was found necessary by the author to ensure that the topic of how to increase flexibility in technical degree plans outside of current paradigms was broached in this forum. If more information is requested, please contact the author of this white paper.

Conclusion

As educators addressing the questions of how best to prepare individuals for the next century -- we need to proceed with caution. We do not want to create more governmentally sanctioned programs for dictating the "appropriate" and "ONLY" course for ensuring student preparation. I am specifically referring to programs such as SCANS (Secretary's Commission on Achieving Necessary Skills). Although these programs receive support from many acclaimed educational organizations, nonprofit foundations, etc; they do little more than change the purpose of education from intellectual development to vocational preparation. Some believe these concerns lie solely with K-12, but the legislation includes and affects post-secondary education. Furthermore, the very study we are participating in has referred to the education reform movement as affecting grade levels K-16 (levels 13-16 refer to the first 4 years of collegiate study). Now is the time to ensure we disassociate ourselves with the K-16 stigma by ensuring that we keep our academic standards of excellence high and that we develop processes by which to ensure student academic success that is transferable and applicable to the work environment of the 21st Century.

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Appendix A