MassTransfer Pathways
Computer Science Group
Fitchburg State University
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Leaders:

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1. Elena Convened the meeting at 10:23 a.m. She welcomed all and explained the objectives for the day.

2. Elena updated the group on the status of *MassTransfer* Pathways, using a PowerPoint presentation.

   a. She reviewed the history of the development of the *MassTransfer* Program from 2009 to the present. Currently *MassTransfer* includes the following components:

      i. General Education Block (*MassTransfer* Block)
      ii. Academic Transfer Pathways
      iii. Course Equivalencies
      iv. Reverse Transfer
      v. Commonwealth Commitment

   b. She reviewed the benefits of the *MassTransfer* Program.

Benefits	Minimum Final GPA			Notes
	2.0+	2.5+	3.0+	
No application fee	✓	✓	✓	*MassTransfer* application required by deadline.
No application essay	✓	✓	✓	
Guaranteed admission		✓	✓	Space permitting in the major and college.
100% tuition waiver *Effective Fall 2016*			✓	For two years, provided student: ▪ Matriculates within one year of receiving associate degree; ▪ Enrolls continuously (full- or part-time) in day programs; and ▪ Achieves 3.0 GPA in first two semesters.

   c. She described how the Department of Higher Education (DHE) is continuing to work to fill in the gaps in the *MassTransfer* Program.

d. She reminded the group of the first six academic disciplines for which 60-credit *MassTransfer* Pathway maps have been developed.

    i. Biology
    ii. Chemistry
    iii. Economics
    iv. History
    v. Political Science
    vi. Psychology

e. She reminded the group of the 10 academic disciplines on which we are working this year and for which 60-credit MassTransfer Pathway maps will be developed next year.

    i. Business Administration
    ii. Communications
    iii. Computer Science
    iv. Criminal Justice
    v. Early Childhood Education
    vi. English
    vii. Liberal Arts
    viii. Mathematics
    ix. Natural and Physical Science Block (STEM)
    x. Sociology

f. She explained that once the 16 academic disciplines are completed they will capture 70% of all students who transfer from Massachusetts community colleges to Massachusetts state universities and campuses of the University of Massachusetts.

g. She indicated that DHE may undertake to develop *MassTransfer* Pathways for Engineering and Nursing during the 2016-2017 academic year, contingent upon funding.

3. Elena provided a brief demonstration of the current MassTransfer Pathways beta website (http://www.mass.edu/masstransfer/pathwaysbeta/).

    a. Elena explained that the Computer Science version of the website will look different from the academic disciplines such as Biology and Chemistry because of the more complicated and varied nature of Computer Science.

    b. In response to a question about how the website will remain current, Elena explained that:

        i. There is currently an annual update process to maintain the currency of course equivalencies; and
        ii. Segmental leaders in each academic discipline will remain engaged with the process going forward.

4. Christine welcomed all attendants and asked them to introduce themselves to the group. She expressed appreciation to the faculty members who have helped to collect syllabi and organize the discussion, as well as Lois Alves, who has helped to develop and organize the materials.

5. Christine reviewed the conclusion of the computer science faculty who attended the *MassTransfer* Pathways Convening on October 16, 2015.

    a. She reviewed the discussion about foundational courses for Computer Science that are not computer science courses.

        i. Calculus I and II: with a presumption that these calculus courses would be engineering-level calculus courses.
        ii. Discrete Math and Linear Algebra: a consensus that students should be strongly encouraged to take these courses.
        iii. Laboratory science sequence: a consensus that students should include one of the following two-semester, eight-credit laboratory science sequences in their programs:

             (a) Chemistry I and II OR
             (b) Physics I and II OR
             (c) Biology I and II.

             Christine invited further discussion of this topic inasmuch as some universities may require physics, while others allow a choice among the three sequences above.

        iv. ABET accreditation: The group discussed the requirements of the Accreditation Board for Engineering and Technology (ABET) for 30 credits of mathematics and science in Computer Science programs.

6. Christine reviewed the six courses for which syllabi had been collected and core course components identified.

    a. Introduction to Computer Science
    b. Computer Programming I and II
    c. Data Structures
    d. Computer Organization and Architecture/Assembly Language
    e. Digital Logic

7. Introduction to Computer Science: The group discussed questions including (a) Is it a survey or programming course? (b) Is it a foundational course? (c) Is it a pre-requisite to other courses? (d) Is it a required course by universities? and (e) What about students whom come to college with high school computer programming coursework?

    The group concluded that it was not necessary to identify the components of the Introduction to Computer Science course because of the variability of components and levels of requirement around the state, but it may be more manageable to consider it as a small block of learning outcomes.

8. The group concluded that rather than approach the task on a course-to-course equivalency basis, it would be more appropriate to reach agreement on a block or package of learning outcomes organized around a small number of topics instead. The proposal was to identify small groups of outcomes that when completed as a group at the community colleges would amount to a number of credits comparable to that taken at the state universities and UMass campuses.

9. Computer Programming I and II: The group agreed that these should be the first two computer courses in a Computer Science program. The group considered including Data Structures to create a block of two or three courses that would constitute the first courses in a Computer Science program. The group then proposed to consider the block as consisting of procedural programming, object-oriented programming and data structures topics, rather than specific courses.

10. Elena suggested that other academic disciplines had decided that it was not always necessary for a course to include all of the components identified. Other disciplines had concluded that if courses covered some percentage, e.g. 70% or 80% or 90% of the components, they would be equivalent. The group decided to identify components that are essential or necessary (underlined below) or optional or recommended (not underlined below). The decided to identify groups of topics, rather than courses, and then identify the essential/necessary and optional/recommended components of those topics.

11. Data Structures

    a. Implement (using linked and array-based implementations), utilize and analyze the following:

         i. Stacks
        ii. Queues
       iii. Lists
        iv. Trees
         v. Balanced trees
        vi. Heaps
       vii. Hash tables
      viii. Graphs
        ix. Maps

    b. Recursion – use, write and analyze
    c. Searching and sorting – $0\,n^2$ and $0\,(n \log n)$

12. Procedural Programming and Concepts

    a. Sequence
    b. Branching
    c. Repetition/iteration/looping
    d. Recursion
    e. Pass by value/pass by reference
    f. Data types
    g. Multi-dimensional arrays
    h. Console and file input/output (I/O)

i.   Procedural abstraction
j.   Dynamic memory management, e.g. malloc and free
k.   Pointers/pointer-based memory management
l.   Memory storage
m. Structures/records
n.   Call stack model

13. Object-oriented programming

a.   Object-oriented model and design of classes
b.   Polymorphism by extension and implementation, including inheritance, interface and abstract class
c.   Encapsulation
d.   Exception handling
e.   Generic types
f.   Abstraction
g.   Graphics
h.   Graphical user interfaces design
i.   Event-driven programming
j.   Multi-threading

14. The group decided to identify the following essential/necessary components for the entire block of procedural programming and concepts, object-oriented programming and data structures:

a.   Best practices

i.   Unit testing
ii. Commenting
iii. Software development processing (process of developing software)

b.   Program design and refactoring
c.   Algorithms
d.   Sequence
e.   Branching
f.   Repetition/iteration/looping
g.   Recursion
h.   Data types
i.   Multi-dimensional arrays
j.   Pass by value/pass by reference
k.

15. Digital Logic

a.   Gates
b.   Data representation

i.   Floating points

        ii.   2's complement
       iii.   Addition
       iv.   Operations on binary data
       v.   Hex/binary

   c.   Sequential combination circuits

       i.   Finite state machine
       ii.   Sum of product/product of sum
       iii.   Flip flops and registers

   d.   Boolean simplification
   e.   Building digital circuits

16. A part of the discussion of Digital Logic led to a discussion of credits, in particular how many credits would be included in the general education/*MassTransfer* block. There is concern that the general education block for Computer Science may not be able to meet the *MassTransfer* Block requirements because it is desirable to leave space in the final two years of baccalaureate study for general education courses. Students need to have a balance of computer science courses and general education courses. A solid schedule of only computer science courses would overwhelm students. The discussion of the general education/*MassTransfer* block resulted in the following.

Subject Areas	Credits	Notes
English composition/writing	6	
Humanities and fine arts	9	Courses may be in either subject area.
Behavioral and social sciences	9	Courses may be in either subject area.
Natural of physical sciences	8	*MassTransfer* Block requires only 7 credits; computer science faculty have specified Chemistry I and II, Physics I and II or Biology I and II; ABET would require one more 4-credit lab science course.
Mathematics/quantitative reasoning	8	*MassTransfer* Block requires only 3 credits; computer science faculty have specified Calculus I and II; ABET would recommend another post calculus course, such as Discrete Mathematics or Linear Algebra.
Sub-total	*40*	
Computer science courses	8-20	Depends on agreement of topic areas to be covered in first two years.
General electives	3-12	Depends on room remaining after computer science courses.
Total	*60*	

The group discussed the possibility that another "hard core" computer science elective could be offered at the community colleges and transfer as a 300-level course at the state universities and UMass campuses.

17. Assembly Language

    a. Instruction mnemonics

        i. Arithmetic/logical operators
        ii. Control and data transfer

    b. Symbolic addresses
    c. Assembler directives
    d. Data representation (binary, hex, floating point) and operations on that data
    e. Stack
    f. Successful program implementation
    g. Accessing memory
    h. Addressing modes
    i. System calls/interrupts
    j. Macros
    k. Input/output (I/O)

18. Computer Organization and Architecture

    a. Von Neumann architecture
    b. Data path and control
    c. Instruction set and machine code
    d. Buses
    e. Arithmetic logic unit (ALU)
    f. Central processing unit (CPU) design
    g. Interrupts
    h. Memory hierarchy, including caches
    i. Input/output (I/O)
    j. Virtualization

19. The group identified the following options for community colleges that could not offer courses such as Computer Organization and Architecture because of enrollment and/or financial constraints.

    a. Discrete mathematics
    b. Linear algebra
    c. "Hard core" computer science coding-based elective that would transfer as a 300-level course at the state universities and UMass campuses
    d. Artificial intelligence (AI)
    e. Robotics
    f. Game programming
    g. Mobile computing
    h. Security software development
    i. Structured query language (SQL)/database modeling/database management systems
    j. Networks
    k. Web development (in JavaScript) or PHP
    l. Software design

m. Simulation and modeling
n. Scientific computing
o. Data science
p. Computer graphics/visualization
q. Computer forensics
r. Security
s. Informatics

20. Christine adjourned the meeting at 2:58 p.m.