Session 3560

Teaching and Learning Effectiveness Planning by Simulation

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Abstract

This paper deals with a concept of computer simulation of teaching and learning, laboratory limitations and resource allocations. This research is an offshoot of present dilemma that arises due to effectiveness of instruction and student skill development in design. Student skills as have been observed depend on one-on-one instruction which requires computer stations and student "intuitive familiarity" gained by diligence and hands on psycho-motor development. The teaching classroom and the cad-lab are connected conjugate processes. Instructions are followed by applicable project based assignment, which is time bound and is to be completed under stress of competition under supervision. Student progress with respect to the assignment that follows the principle and theory and its application require student conformance to a compelling monitoring process. This monitoring method applies "student performance quality control" in real time basis in a stringently supervised CADLAB, as though student conformance to design assignment is either a good product or a defective product. This study uses computer simulation with General Purpose System Simulator (GPSS/H) to (a) measure effectiveness of CADLAB teaching and learning, (b) plan for cad-lab activities and estimate utilization, and (c) monitor and improve cad-lab performance under severe resource limitations.

Introduction

Effective Teaching of Computer Aided Design necessitates strong student learning experiences demonstrating abilities as outcomes of "Affective Behavior." An affective behavior is a behavior that is demonstrated by the student as an act of competence or show of confidence. In an introductory level course, a student after completion of about only twenty eight lessons of one hour each must be able to demonstrate effective learning in higher level cognitive, affective and psychomotor domain showing that he/she is capable of modeling in 2D and 3D. Again, five skills exams administered per semester bring the total class meetings to only twenty-three. The effectiveness of this project based CAD teaching and learning is limited to demonstration type of teaching in a lecture format for one hour and letting loose the students to complete assignments and projects by their own volition and cooperation. No monitoring is possible in the lab. There is no "practical" cad-lab with supervised lab experiences for the students. Therefore, the students are supposed to complete drawing and project assignments in unsupervised labs in their own time. This gives rise to too much cooperation among the students, to say the least, where a student's original work is compromised. With due regards to students' work, it can be said that serious ethical violations are not frequently encountered or suspected. However, the responsibility of correct assessment of student's work lies solely on the instructor. Objective exams are given separately to assess concepts and processes in engineering design, visualization, 2D and 3D Modeling. Five three-hour skills exams are administered under supervised instructional control condition to ascertain the "design process" ability and applicability of students in two dimensional and three dimensional modeling framework to judge their competency based "affect" and mastery of the subject learned. This concept has been discussed here in a lab-controlled environment.

The Theory of Teaching Effectiveness

The fine art of effective teaching is not doing things that are not now pertinent for the class, not doing things prematurely in the class, not doing those things that cannot be received effectively, and not teaching those things that others should teach elsewhere.

The Learning Simulation Model

The cad-lab has been "modeled" as a production shop with quality conformance in mind. Activities in this lab have been modeled in GPSS simulation for a problem that allows a student to complete the competency level and gain mastery in modeling within three hours of supervised set up. Every lab is considered as a complete or incomplete student performance. If a student could not complete the assignment under instructor guidance he is considered as having failed in that level of competency and is required to complete that assignment under the supervision of a graduate student monitor. Every lab has the urgency and promptness of an exam set-up. The rigor of competition is applied. It is this level of urgency of "competing value framework" (CVF) or "the sense of competition" that is being applied as a measure of teaching and learning experience. Healthy competition with an expectation for reward in completing the project right (mastery learning) is assessed here. Since this is lab-exam situation the cognitive and affective level of the student is normally high, as they have been adequately prepared for this event.

Explanation of the Learning Model

Flow Diagram Schematic at Fig. 1, program code at Fig. 2, and simulation run at Fig. 3 in the appendix, suggest that the students are moving in the system as transactions. This cad-lab is conceived as a manufacturing, assembling and quality testing system. The engineering cad-lab is identical to the following queuing line hypothetical situation.

Statement of the manufacturing simulation problem

Assembled television sets move through a series of testing stations in the final stage of their production. At the last of these stations, the vertical control component on the sets is tested. If the component is not working correctly, the defective set is routed to an adjustment station, where the component is modified. After adjustment the set is sent back to the last inspection station, where the component is again inspected. If the set again fails inspection, it is again routed to the adjustment station, and so on. Sets passing the final inspection phase, whether the first time or after one or more routings through the adjustment station, move on to exit system as good television sets.

Statement of the cad-lab simulation problem

Students who have attended a fifty minute in-class demonstration of cad modeling problem and its solution are given similar assignment problem to be completed in the lab for demonstration of proficiency and mastery with zero tolerance of defects in the solution. Students after completing the initial tasks move through a series of testing stations manned by graduate students in the final stage of their drawing completion. At the last of these stations, the 3D model and extracted orthographic 2D drawing with details of dimension, tolerance and fits on the on the drawing is tested. If the 2D details and 3D Model are not completely correct, the defective model-drawing is routed to an advisement/ adjustment station, where the component is modified under specific instruction. After revision implementation the drawing is sent back to the last inspection station, where the drawing is again inspected. If the model-drawing again fails inspection, it is again routed to the advisement/ adjustment station, and so on. Drawings passing the final inspection phase, whether the first time or after one or more routings through the adjustment station, move on as having acquired mastery in that phase of skill.

The situation is depicted in the figure attached: flow schematic for teaching and testing stations. The circles represent students with their completed works for testing/ evaluation and advisement if found defective. The x-ed out circles are defective student works that are either worked on the adjustment station or are waiting to be worked on here. The testers are the two graduate students who check the initial student work. The adjuster is the instructor who finally approves the final drawing.. The rejection rate is fifty percent, so about half the class will be going around at least once. If more resources were available, there will be more testers and more adjusters with the failure rate being as high as eighty five percent which will take more time for the simulation to end as everybody completes the mastery level work. Resource allocation of staff can be made by simulating the difficulty level of the problem. For a higher order assembly and tolerance problem the simulation will predict that we need at least eight hours for the twenty five students to go through complete mastery level with three testers and one teacher/ adjuster.

Students arrive at their cad-lab stations, with their assignments, from the conjugate classroom next door after an hour of in-class demonstration. They are allowed to work on the assignment for an hour independently without any further instruction. After this time the testers and the adjusters occupy their respective positions. The students then arrive to the testing stations wit an inter-arrival time of 5 ± 2 minutes. Two graduate students work side by side at the inspection station. The time required to inspect a completed drawing is 8 ± 3 minutes. Because the product on the first pass is very poorly designed only fifty percent of the students pass inspection and continue on to exit off the system. (This percentage is assumed to be independent of the number of times attempts have been made to adjust/ correct the product. This realistic assumption fifty percent failure rate can be tightened can be tightened.) The other fifty percent are routed to the adjuster / instructor where there is only one single server. Adjustment and advisement takes 10 with their assignment 10 ± 2 minutes.

This cad-lab model has been designed to predict the utilization of teacher and graduate assistant and lab resource reservation so that a plan could be submitted to the administrator for planned resource reservation and utilization. This pre-empts effective classroom and lab behavior on the par of the students. It assists the teacher to estimate precisely how much staging space should be provided ahead of the inspection/testing station and ahead of the adjustment/advise section. (Staging space is the space occupied by work waiting for service to begin.) Transaction movement should end when the last student 25 exits the system with a mastery level work done. It is necessary to know how much simulated time has elapsed when this condition is reached so that the lab resources will be dispersed.

Results and Analysis of the Simulation

The simulation lasted for 154 minutes or two hours and 34 minutes, allowing for the last student transaction to exit out of the system successfully completing the project. The two testers were “storage blocks” like graduate “tellers” helping students to complete assignments. If any one of the two testers was busy the student will have consulted the second without waiting in the queue called LASTTEST. The testers’ average utilization was 94.4% (i.e. TESTERS were busy 94.4% of the time correcting the initial student works). The average time taken by each student with the TESTERS was 7.838 minutes. TESTERS were visited by 37 students. Twenty five students were processed but twelve of them had to repeat the assignment after being seen by the testers. The adjuster/ teacher utilization was 71.3%. The average time taken by each student when s/he was visiting with the adjuster/teacher facility was 9.965 minutes. The adjuster /teacher facility was visited by 11 students. There are two queues formed. One was a queue for testers called LASTTEST and the other was for adjuster called ADJUSTQ. The run statistics for LASTTEST were: maximum queue length at any moment was 5. Average queue length was 2.426. Total number of students that went through this queue was 42. Three went into service without waiting to be served and these comprise of 7.1% of the total. Total average time per student waiting in this queue was 9.559 minutes. The run statistics for ADJUSTQ were: maximum queue length at any moment was 2. Average queue length was 0.193. Total number of students that went through this queue was 11. Six went into service without waiting and these comprise of 54.5% of the total. Total average time per student waiting in this queue to be served was 5.993 minutes.

The queue statistics and the server characteristics indicate the effectiveness of the cad-lab system as it is planned now. Additional resource allocation may be planned to improve the overall ‘system’ for improved performance with regards to those performance indicators discussed above i.e., TESTERS, ADJUSTER, LAASTTEST, ADJUSTQ.

Conclusions

The main conclusion is that design based assignments and cad-lab assignment and competitions offer a superb way of creating enthusiasm and reinforcement of learning in the students with demonstration of better skills, behavior and professional attitude. Competing value framework can be used to evaluate learning outcomes at all levels of engineering and applied technological education. The simulation offers effective use of student and instructor time and better utilization for scarce resources that need to be shared. The principal requirement of this method is that the process must continually elevate the standards of achievement and must always provide students with immediate feedback on their quality of conformance to the standards.

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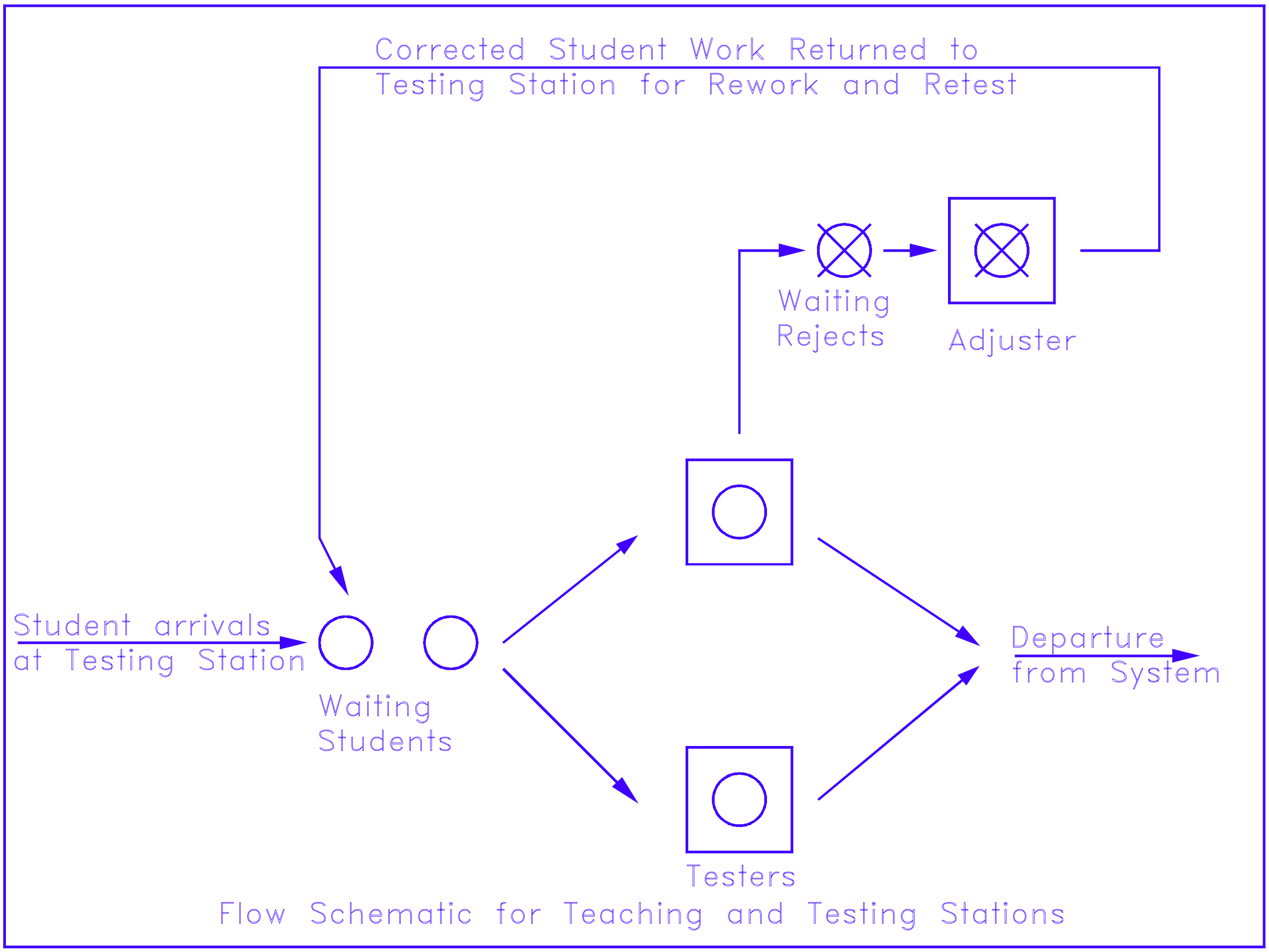

Figure 1: Simulation Flow Diagram of Student Arrival, Queues, Servers (Testers) and Facility (Adjuster)

********************* SIMULATION PROGRAM CODES ***********************

```
            SIMULATE            Case Study: Modeling CAD lecture and Lab
   *                            A Quality Control Model of Enhancing learning By
   *                            Routing
   *                            Base Time Unit: 1 Minute
**********************************************************************
*         Control Statements (STORAGE)                               *
**********************************************************************
*
 TESTERS  STORAGE    2        Testers (graduate assistants) placed at last
*                             test-station to assist in checking draft copy
*
**********************************************************************
*         Model Segment 1 (Last Test Station)                        *
**********************************************************************
*
          GENERATE   5,2      Students arrive one by one, after an hour of
*                             supervised independent work, to the help and
*                             checking stations either with complete work
*                             or incomplete work
 RETEST   QUEUE      LASTTEST start LASTTEST Queue membership
          ENTER      TESTERS  request/capture a tester
          DEPART     LASTTEST end LASTTEST Queue membership
          ADVANCE    8,3      pass/fail test for competency; if deficient
*                             re-rout to quality control examiner for remedial
*                             work; or "exit" out of system if competent
          LEAVE      TESTERS  Let go the tester
*
 TRANSFER   .50,,ADJUSTIT     50% must pass/fail set within system
*
          TERMINATE  1        the rest of competent/passed students leave lab
*
**********************************************************************
*         Model Segment 2 (Adjustment Station)                       *
**********************************************************************
*
 ADJUSTIT QUEUE      ADJUSTQ  Start ADJUSTQ Queue membership for remedial lesson
          SEIZE      ADJUSTER request/capture the adjuster / examiner
          DEPART     ADJUSTQ  end ADJUSTQ Queue membership
          ADVANCE    10,2     adjust remedial consultation work with examiner
          RELEASE    ADJUSTER free the adjuster/ examiner (complete assignment)
          TRANSFER   ,RETEST  transfer to re-testing (graduate assistants)
*
**********************************************************************
*         Run-Control Statements                                     *
**********************************************************************
*
          START      25       set Total Count TC=25; start Xact (Transaction)
*                             movement
*
          END                 end of Model-File execution
*
```

Figure 2: GPSS Simulation Program of CADLAB Activities for a Total of 25 Students Completing Assignments with Mastery under a condition of Competition.

```
****************************************************************************************************
  STUDENT GPSS/H RELEASE 2.0 (AY130)  23 Apr 1999  11:45:16  FILE: modeling.gps

   LINE# STMT#  IF DO  BLOCK#  *LOC   OPERATION      A,B,C,D,E,F,G  COMMENTS

       1     1                        SIMULATE             Case Study: modeling CAD lecture and lab
       2     2                 *                           A Quality Control Model of enhancing learning
       3     3                 *                           Base Time Unit: 1 Minute
       4     4                 ********************************************************************
       5     5                 *         Control Statements (STORAGE)                             *
       6     6                 ********************************************************************
       7     7                 *
       8     8                  TESTERS  STORAGE    2          testers (graduate assistants) placed at last
       9     9                 *                               test station to assist in checking draft copy
      10    10                 *
      11    11                 ********************************************************************
      12    12                 *         Model Segment 1 (Last Test Station)                      *
      13    13                 ********************************************************************
      14    14                 *
      15    15              1            GENERATE   5,2        students arrive one by one, after an hour of
      16    16                 *                               supervised independent work, to the help and
      17    17                 *                               checking stations either with complete work
      18    18                 *                               or incomplete work
      19    19              2   RETEST   QUEUE      LASTTEST   start LASTTEST Queue membership
      20    20              3            ENTER      TESTERS    request/capture a tester
      21    21              4            DEPART     LASTTEST   end LASTTEST Queue membership
      22    22              5            ADVANCE    8,3        pass/fail test for competency; if deficient
      23    23                 *                               re-rout to quality control examiner; remedial
      24    24                 *                               work; or "exit" out of system if competent
      25    25              6            LEAVE      TESTERS    let go tester
      26    26                 *
      27    27              7            TRANSFER   .50,,ADJUSTIT  50% must pass/fail set within the system
      28    28                 *
      29    29              8            TERMINATE  1          rest of competent/passed students leave lab
      30    30                 *
      31    31                 ********************************************************************
      32    32                 *         Model Segment 2 (Adjustment Station)                     *
      33    33                 ********************************************************************
      34    34                 *
      35    35              9   ADJUSTIT QUEUE      ADJUSTQ    Get ADJUSTQ Queue membership remedial lesson
      36    36             10            SEIZE      ADJUSTER   request/capture the adjuster / examiner
      37    37             11            DEPART     ADJUSTQ    end ADJUSTQ Queue membership
      38    38             12            ADVANCE    10,2       adjustment remedial consultation w/ examiner
      39    39             13            RELEASE    ADJUSTER   free adjuster/examiner(complete assignment)
      40    40             14            TRANSFER   ,RETEST    transfer to re-testing (graduate assistants)
      41    41                 *
      42    42                 ********************************************************************
      43    43                 *         Run-Control Statements                                   *
      44    44                 ********************************************************************
      45    45                 *
      46    46                        START      25         set TC=25; start Xact movement
      47    47                 *
      48    48                        END                   end of Model-File execution

****************************************************************************************************
ENTITY DICTIONARY (IN ASCENDING ORDER BY ENTITY NUMBER; "*" => VALUE CONFLICT.)

       Facilities: 1=ADJUSTER

       Queues: 1=LASTTEST      2=ADJUSTQ

       Storages: 1=TESTERS
----------------------------------------------------------------------------------------------------

SYMBOL    VALUE   EQU DEFNS  CONTEXT      REFERENCES BY STATEMENT NUMBER
ADJUSTIT     9          35  Block          27
RETEST       2          19  Block          40
ADJUSTER     1              Facility       36    39
ADJUSTQ      2              Queue          35    37
```

LASTTEST	1		Queue	19	21
TESTERS	1	8	Storage	20	25

STORAGE REQUIREMENTS (BYTES)

COMPILED CODE:	406
COMPILED DATA:	40
MISCELLANEOUS:	0
ENTITIES:	488
COMMON:	10000
TOTAL:	10934

Simulation begins.

RELATIVE CLOCK: 153.6723 ABSOLUTE CLOCK: 153.6723

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1		31	11		11
RETEST	**5**	**42**	12		11
3		37	13		11
4		37	14		11
5	1	37			
6		36			
7		36			
8		25			
ADJUSTIT		**1**1			
10		11			

FACILITY	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/XACT	CURRENT STATUS	PERCENT AVAIL	SEIZING XACT	PREEMPTING XACT
ADJUSTER	**0.713**			**11**	**9.965**	**AVAIL**			

STORAGE	--AVG-UTIL-DURING-- TOTAL TIME	AVAIL TIME	UNAVL TIME	ENTRIES	AVERAGE TIME/UNIT	CURRENT STATUS	PERCENT AVAIL	CAPACITY	AVERAGE CONTENTS	CURRENT CONTENTS	MAXM CONT.
TESTERS	**0.944**			**37**	**7.838**	**AVAIL**	**100.0**	**2**	**1.887**	**1**	**2**

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/UNIT	$AVERAGE TIME/UNIT	QTABLE NUMBER	CUR CONT
LASTTEST	**5**	**2.426**	**42**	**3**	**7.1**	**8.876**	**9.559**		**5**
ADJUSTQ	**2**	**0.193**	**11**	**6**	**54.5**	**2.697**	**5.933**		**0**

RANDOM STREAM	ANTITHETIC VARIATES	INITIAL POSITION	CURRENT POSITION	SAMPLE COUNT	CHI-SQUARE UNIFORMITY
1	OFF	100000	100116	116	0.19

STATUS OF COMMON STORAGE

8992 BYTES AVAILABLE
1008 IN USE

```
    1248 USED (MAX)

Simulation terminated.  Absolute Clock: 153.6723
***************************************************************************************************************
Total Block Executions: 347

Blocks / second:        347000

Microseconds / Block:   2.88


Elapsed Time Used (SEC)
PASS2:           0.05
EXECUTION:       0.00
---------------------
TOTAL:           0.05
***************************************************************************
```

Figure 3: The Result of Simulation with Facility & Resource Utilization Indices

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Hamid Khan is an Assistant Professor in the School of Industry and Technology of East Carolina University. His teaching interest is focused on Computer Aided Machine and Tool Design, Computer Graphics, Concurrent Engineering in Mechanical Design, and CAD/CAM/CAE/and RP. His research interest is focused on the above as well professional development of Professional Engineering and Technology Managers to integrate teaching for practice. Dr. Khan has a BS in Mechanical Engineering, an MS in Industrial and Management Systems Engineering, an MBA in Production Strategy and a Doctorate in Management Education. Hamid is a Registered Professional Engineer. He is active in the ASEE's Engineering Technology Division, Educational Research and Methods Division, and Computers in Education Division. He is also active in IEEE/Frontiers in Education conferences. He has published and presented about twenty-five papers in their annual proceedings and conferences. Hamid has served as a reviewer for the ASEE's ERM, International, manufacturing Divisions for the Frontiers in Education proceeding papers. He has served as a judge for International Design competitions conducted annually by the auspices of Addison Wesley/Engineering Design Graphics Division of ASEE and as a reviewer for Ben Dasher best paper award nominations for the Frontiers in Education.
