Some Tested Methods and Tools for Real-life Exposure in an Academic Setting for Millennial Generation Engineering Students

by
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Abstract

Millennial generation students are interested in an integrated, simultaneously analytical, computational, interactive, as well as practical, real-world-focused, customized education. They expect a large number of choices, because they understand the power of simulation. They are very visually focused, because this is the video gaming generation. They want personalized, customized products, processes and service, and their education process is not an exception. They look for technical details, and want to see it all; immediately, and virtually...They look for good quality and low cost and ease of use, and interactivity, because there is NO time to read traditional manuals and static textbooks… They like to continuously explore, experiment, rather than follow the traditional path. They also have less need and desire to conform. They expect instant gratification. They are often impatient, and therefore want it immediately…

The important observation here is that all of these attributes should be respected, and that the education system should adjust to delivering these customer expectations at a high quality level. In this paper some tested pedagogical as well as advanced educational technology methods and tools are discussed, and demonstrated to satisfy the above requirements for both live and distance learning (DL) classes.

Introduction

The objective of this research was to create a case-based / problem-based teaching and learning curriculum for Millennial generation engineering and IT students. In order to satisfy the need of an integrated, simultaneously analytical, computational, interactive, as well as practical, real-world-focused, customized education, we have developed an advanced 3D web-enabled active-code case library, supported by on-line features, DVD full-screen videos and even by smaller-size video iPod videos.

Our solution enables students to explore and analyze real-world processes, requirements, risks, 3D simulation, statistical analysis and design of experiment cases, following an analytical, 3D interactive multimedia approach. We demonstrate our method as applied to industrial engineering science, engineering management, design and manufacturing engineering, quality control, biomedical engineering, computer systems, networking subjects, and others, with the aid of a generic architecture. In terms of our basic methods, we deploy web-browser readable multimedia, text, images, interactive videos, 2D and 3D animations, active code for calculations, simulation programs, and even self-assessment tools.

Our educational and computational methods introduce a novel approach to developing and running undergraduate and graduate courses for face-to-face, hybrid (or blended), on-site professional, and distance learning (i.e. eLearning) modes.

In this paper we introduce the principles of our educational methods and solutions, and explain and demonstrate (during our live presentation) a series of case-based learning modules (using interactive 3D eBooks, supported by DVD videos) that encourage analytical and team-oriented learning and problem-solving with real-world challenges. (At the time of writing, our library has over twenty 3D eBooks and over 150 full screen DVD videos covering US and international virtual factory tours, research cases and in-depth product, process, service system demonstrations by field experts and other professionals.)

Our efforts are supported by over 200 academic and industrial partners world-wide, assuring the diversity, the relevance and the quality of this rapidly growing library and teaching / learning method.

Millennial Generation Engineering Student Requirements Analysis

Millennial generation students around the globe are interested in an integrated, simultaneously analytical, computational, interactive, as well as practical, real-world-focused, customized education. They expect continuous excitement, and challenging, real-world examples that help them to learn analytical concepts.

They are used to dealing with a large number of choices, because they understand the power of 3D interactive simulation. They are very visually focused, because this is the video gaming generation. They want personalized, customized products, processes and service, and their education process is not an exception. They look for technical details, and want to see it all; immediately, and virtually...

They look for good quality and low cost, ease of use, because there is NO time to read traditional manuals and static textbooks… They like to continuously explore, experiment, rather than follow the traditional path. They also have less need and desire to conform, expect instant gratification. They are often impatient, and therefore want it immediately…

The important observation here is that all of these attributes should be respected, and that the education system should adjust to delivering these customer expectations at a high quality level. Based on 12+ years of continuous development, field testing, and over 10000 undergraduate and graduate assignments submitted, our advanced content library and tested pedagogical methods and tools satisfy the above requirements.

In this paper we focus on our generic methodology, and illustrate some engineering applications ([1], [2] and [12]). As a generic, object-oriented engineering management problem solving method, as with all cases in our library of cases, we are committed to the following approach:

- Analyze the needs and the requirements, the demonstrated processes, methods and systems they try to, or have to satisfy.
- Analyze the actual methods presented. Find the core methodologies, the mathematical models, the underlying engineering (and/or other) science foundation.
- Analyze the technologies involved. (How is science turned into a practical solution/ engineering and/or computing technology?)
- Analyze and review the actual processes and the way the process flow is integrated. (Follow an object-oriented process analysis method, e.g. from concept to product.)
- Analyze potential alternative solutions.
- Analyze the benefits and the disadvantages of each process/ solution.
- Design alternative methods, processes based on what you have experienced/ seen, and learned.
- Design an integrated system, based on what you have analyzed in this case. (Preferably use web-based, open source tools and knowledge documentation systems, because this will encourage every member of the team to participate, as well develop the methods further, so that they become 'living documents'.)
- Work in a multi-disciplinary team and exchange ideas, because this way the engineering management team will become stronger, and their decisions better.
- Understand the boundaries as well as the tremendous potential of new ideas and developments by working on this case. (Realize that in order to survive and win, you must add value.)

The above challenges are presented to students using 3D interactive virtual environments of real-world challenges (see Figures 1 and 2). (Note, that the virtual approach here helps to bring students to advanced, industrial and research facilities, that would otherwise be impossible to reach, due to cost, time and other constraints.)

Furthermore, the expert guided in-depth discussions, the interactive tours, the text and other 2D and 3D media, the DVD and iPod videos, the worked out case-examples, as well as the active code in our cases offered help students to grasp the method, and then use the active code for calculating with their own data.

Some Architectural Design Methods and Solutions

In this library we follow an object / component-oriented design approach, therefore the open systems architecture includes key design principles ([6] to [11]). The Case-based library programs are self contained objects built of reusable objects and components. Often, these objects and components are text, high quality images, interactive digital 2D videos, 2D and 3D animation, 3DVR (3D virtual reality) objects, animated 360 degree 3D panoramas, active code spreadsheets, simulation programs, and others.

They are open source, web-enabled, delivered on CD-ROM or DVDs, or fast university / company intranets, the new emerging opportunity for continuous professional development. The way we present challenges are similar to the way professional engineers, and engineering managers solve problems. Millennial engineering students like this approach. This is because we first look at the real-world customer requirement, then offer one or more solutions by explaining real-world machines, or processes, or systems, or management tasks and then discuss further development, service, maintenance, integration, connectivity and many other issues with several feedback loops, and then offer discussion opportunities for real or virtual teams. In all cases the library modules show high quality, interactive videos and often 3D objects and 360 degree interactive panoramas so that learners can interrogate objects, take products virtually apart in 3D, enjoy virtual factory or facility tours and even participate/ collaborate actively by e-mail and other Internet methods.

In terms of challenging the learner to learn and investigate the illustrated case(s) further the cases give them several direct URL (web) contacts, e-mail addresses so that they can get in touch with anybody over the web, including any of the authors who have created/ presented the cases. In several cases, assessment is supported by spreadsheet-based automated tools, that in case of an incorrect answer hyper-links the learner back to a variety of revision solutions, so that the missed material can be learned, and the test re-taken. The assessment questions address exciting engineering, management, and computing science / IT (Information Technology), biomedical engineering, and other issues, and in many cases document best practices. This approach helps distance learners as well as educators to work with the material in real-world classroom and/or virtually web-networked teams.

The cases are object-oriented and self-contained, nevertheless can be integrated/ grouped into different classes of objects in a lean and flexible way (the same way as a modern software program, or a modern manufacturing / assembly system can be integrated into different environments). This enables learners as well as tutors and managers to 'plug-and-play' the Library cases in the way they choose to, rather than the way the author meant it. This means that our 'typical' readers are problem solvers, as well as readers and authors at the same time... an interesting challenge for all of us.

The ways we present challenges are very similar to the way professional engineers solve problems. Notice that we do not follow the traditional linear, but rather the modern concurrent, object oriented approach to integrated product/ process design ([7], and [8] and [11] to [13]). The methodology we follow enables basic knowledge transfer enabled with interactive multimedia. It is highly interactive, collaborative and enables large groups as well as individuals to gain the same knowledge effectively ([1]). Although this method is not for everybody because the problems as well as the solutions are interdisciplinary, often open-ended and can get complex, in all cases our solution will enhance, support and enable a wide range of interactions with real-world challenges ([11] to [15]).

The benefits of introducing problems for students to solve using cases in a browser-readable 3DVR interactive multimedia format are manifold. The entire learning process becomes more student- versus lecture- or tutor-centered. Students can learn by exploring versus being told, and can have as many goes at solving a problem, or exploring an idea, taking as much time as desired or is available. Mistakes made can be corrected without penalties. Multimedia tools, or a subset of such technology and a variety of media, are available during the learning process.

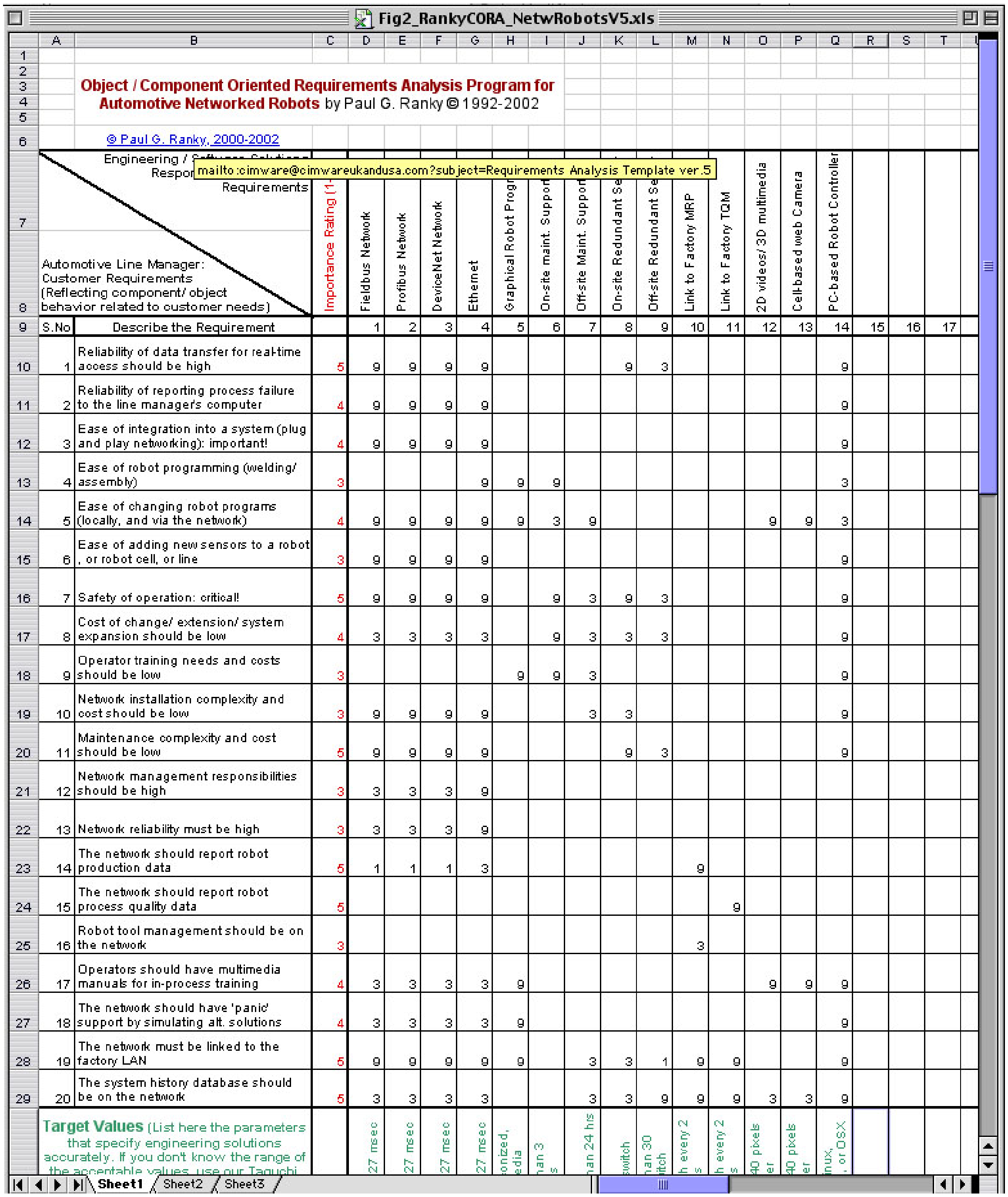
Within our cases self-assessment is possible. This means that students become more self-critical as they participate directly in their own learning process. Team, group and class assessment is integrated into every module of our programs (supported by active code spreadsheets, often with embedded 3D objects, video-clips and animations) that the students can interrogate to understand either the question(s) or the answers better. Furthermore, in our assessment programs graphs are shown illustrating individual vs. group/class benchmark assessment results. This is very useful, in particular for distance learning students, because they feel that they are equal members of the class. (Traditional, as well as e-mail, web-collaborative, telephone and personal-appointment-based tutorial support is available if required.) As a result, the entire education process is more suited to satisfy individual needs from 'batch size 1 to many' at the same high quality ([14] and [15]).

The most important design feature of our object oriented system architecture is that there is only one core, reusable electronic document, built of 3D web-objects, and active code, that has to be authored and maintained. This enables a wide variety of users/viewers to occasionally become authors (via the appropriate security gates and web-technology) feeding useful knowledge into the content of the object and component oriented architecture. As an example of a learning-object, in **Figure 1**, we illustrate a Component-oriented Requirements Analysis (CORA) matrix-based method, similar to QFD (Quality Function Deployment) practices, developed for user requirement / need analysis.

As can be seen in Figure 1, the team enters the

1. User requirements in the left hand side of the matrix, including their
2. Priority ratings, then the
3. Selected engineering solutions (at the top of the matrix) and then the
4. Correlation values (1, or 3, or 9) linking requirements and engineering solutions in the actual matrix (middle section of the spreadsheet).

It should be noted, that we enter data into a CORA spreadsheet on a relative scale, therefore standards should be determined by the local CORA Team, as well as by the local, customized standards they follow. As a result of our team efforts, the CORA software tool calculates absolute and relative importance ratings, and guides the team on where to put critical resources for improving customer satisfaction, quality, and others. To illustrate some aspects of our interactive, 3D browser readable eLearning architecture, in **Figure 1**, we present a typical screen segment of a specific requirements analysis case. (Note, that some of these cells link to various additional 3D interactive multimedia, or active code. Please visit http://www.cimwareukandusa.com, to review more examples.)



S.No	Describe the Requirement	Importance Rating (1-	Fieldbus Network	Profibus Network	DeviceNet Network	Ethernet	Graphical Robot Progr	On-site maint. Support	Off-site Maint. Support	On-site Redundant Se	Off-site Redundant Se	Link to Factory MRP	Link to Factory TQM	2D videos/ 3D multimedia	Cell-based web Camera	PC-based Robot Controller			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Reliability of data transfer for real-time access should be high	5	9	9	9	9				9	3					9			
2	Reliability of reporting process failure to the line manager's computer	4	9	9	9	9										9			
3	Ease of integration into a system (plug and play networking): important!	4	9	9	9	9										9			
4	Ease of robot programming (welding/ assembly)	3				9	9	9								3			
5	Ease of changing robot programs (locally, and via the network)	4	9	9	9	9	9	3	9					9	9	3			
6	Ease of adding new sensors to a robot, or robot cell, or line	3	9	9	9	9										9			
7	Safety of operation: critical!	5	9	9	9	9		9	3	9	3					9			
8	Cost of change/ extension/ system expansion should be low	4	3	3	3	3		9	3	3	3					9			
9	Operator training needs and costs should be low	3					9	9	3							9			
10	Network installation complexity and cost should be low	3	9	9	9	9			3	3						9			
11	Maintenance complexity and cost should be low	5	9	9	9	9				9	3					9			
12	Network management responsibilities should be high	3	3	3	3	9													
13	Network reliability must be high	3	3	3	3	9													
14	The network should report robot production data	5	1	1	1	3						9							
15	The network should report robot process quality data	5											9						
16	Robot tool management should be on the network	3										3							
17	Operators should have multimedia manuals for in-process training	4	3	3	3	3	9							9	9	9			
18	The network should have 'panic' support by simulating alt. solutions	4	3	3	3	3	9									9			
19	The network must be linked to the factory LAN	5	9	9	9	9	9		3	3	1	9	9			9			
20	The system history database should be on the network	5	3	3	3	3			3	3	9	9	9	3	3	9			
Target Values (List here the parameters that specify engineering solutions accurately. If you don't know the range of the acceptable values, use our Taguchi			27 msec	27 msec	27 msec	27 msec	onized, edia	han 3 s	han 24 hrs	switch	han 30 itch	h every 2 s	h every 2 s	40 pixels er	40 pixels er	inux, , or OSX			

Figure 2 (below) illustrates further screen segments, that enable students to actively manipulate real-world photo-realistic virtual 3D objects, and explore customer requirements following our analytical approach.

Note, that according to our experience, this approach keeps the students interested in the subject they learn, because they can actively interact with the computer, showing them exciting 3D interactive animations, and active code they can run with their own data, all under their control. (Please note, that our original screens are in high quality, full screen and full color graphics that we had to reduce in size and quality to fit the format requirements of this paper.)

Figure 2 illustrates an interactive 3D virtual reality object that enables students to explore an-in-depth view of the discussed subject area. (Please visit http://www.cimwareukandusa.com, to review the above interactive 3D rapid prototyped objects in color in our library).

Figure 3 (below) illustrates several interactive 3D simulation examples of a modern, visual and flexible factory. Such examples and advanced 3D learning resources support Millennial students in their desires to explore, review, interact and learn at their own pace.

Summary and Conclusions

Our 3D multimedia learning eBooks, DVD videos and active code programs have been validated and tested in several industry and university (live and virtual) classes, involving thousands of undergraduate and graduate Millennial students. The subjects include Industrial Engineering, Mechanical Engineering, Manufacturing Systems Engineering, Information Technology, Information Systems, Visual Factory Management, Total Quality Management, Product Lifecycle Management, Concurrent Engineering, Robotics, Lean Manufacturing, Warehousing and Logistics, and many others.

This work is the result of several years of on-going R&D. It started in 1977-78. Since then the topic as well as the architecture has evolved into a robust, object-oriented knowledge management architecture with 3D web-objects, DVD videos, active code programs, and others, supported by several companies and institutions. Our efforts have been validated and strongly supported most importantly by our undergraduate and graduate engineering, engineering management and computing students at NJIT, and elsewhere in the world, who have worked through different versions of our library and helped us shaping it to its current, robust multi-platform format. Based on feedback obtained from the students who are using this library, the 2006 surveys clearly indicated, that Millennial generation students prefer 3D interactive learning resources, rather than traditional static books. We would like to thank for the continuous support of our students, the companies and organizations, and pleased to report that our efforts are moving on with an increasingly positive energy flow in all of us involved.

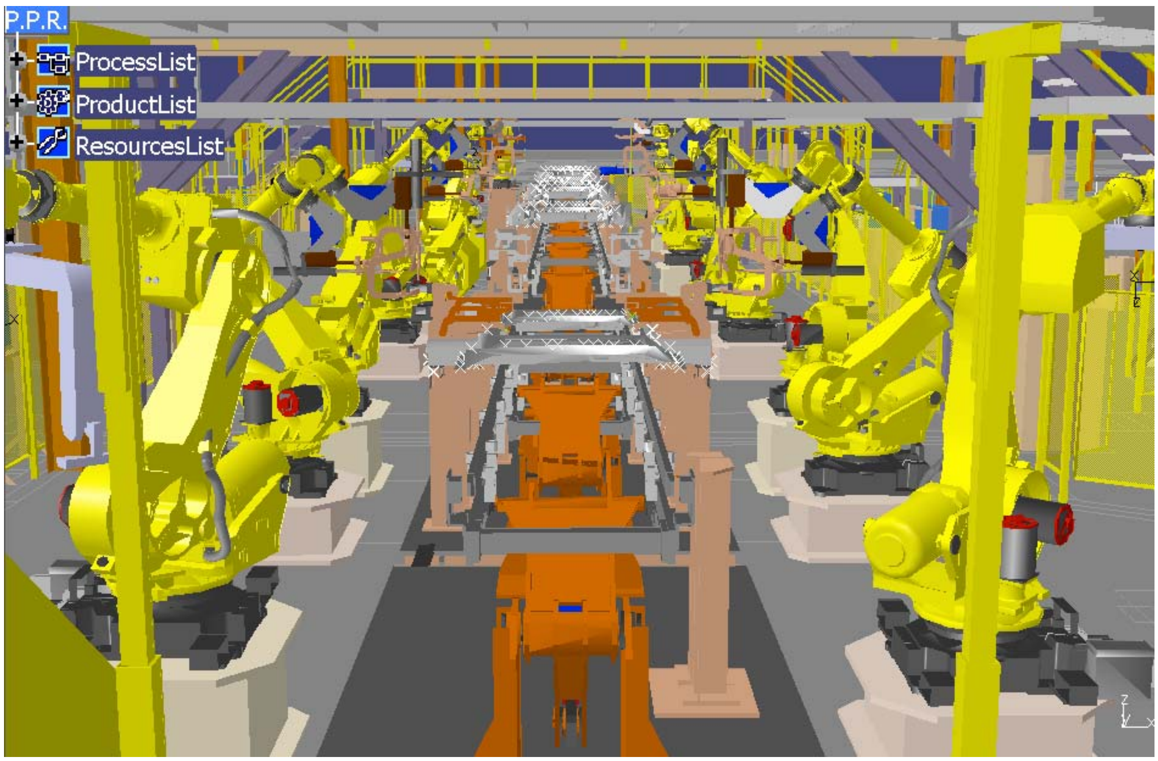


Figure 3 illustrates several interactive 3D simulation examples of a modern, visual and flexible factory. Such examples and advanced 3D learning resources support Millennial students in their desires to explore, review, interact and learn at their own pace. (Please visit http://www.cimwareukandusa.com, to review the related PLM, Product Lifecycle Management educational resource demonstrations on the web.)

Live Software Demonstration
During the presentation of this paper at the conference there will be several live software demonstrations.

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