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SUMMARY

1. PURPOSE. To provide security and policy review on the document at Tab 1 prior to release to the public.

2. BACKGROUND.

Authors: Maj Paul H. Abair, PhD

Title: Integrating Virtual Simulations

Circle one: Abstract Tech Report Journal Article Speech Paper Presentation Poster
Thesis/Dissertation Book Other: _____

Check all that apply (For Communications Purposes):

☐ CRADA (Cooperative Research and Development Agreement) exists

☐ Photo/ Video Opportunities ☐ STEM-outreach Related ☒ New Invention/ Discovery/ Patent

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3. DISCUSSION. N/A

4. RECOMMENDATION. Sign Coord block above indicating document is suitable for public release. Suitability is based solely on the document being unclassified, not jeopardizing DoD interests, and accurately portraying official policy.

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1 Tab
1. Integrating Virtual Simulations

Practitioners' Corner

Integrating Virtual Simulations

Paul H. Abair, PhD

The author explores the theory of simulations; explains current trends in instructional theory, digital media, and change management; discusses the impact on instructional and simulation development design; provides an integrated simulation development and implementation model; and provides recommendations for practitioners who are ready to cross the threshold of integrating software-based simulations into their learning environment. Current trends of pervasive computations, contextual fidelity, increasing demand for flexible constructive learning environments, and improved affordability suggest that digital simulations are likely to play a larger role in mainstream education and learning in the 21st century.

Theory of Simulations in Learning

Simulations are fictitious representations of reality created to exercise learned skills and applied knowledge to situations that are too costly to replicate in the real world. The term suggests that doing what is real is impractical. Emerging trends in pervasive computations, high-definition animation engines, increased processor speeds, and cloud computing are catapulting the industry of simulation innovations and changing the equation for determining what is impractical for education and training.

The development of flight simulators made perfect sense for reducing the costs and risks associated with increasing actual flight time for novice pilots. The cost of developing flight simulators could be depreciated by time and scale, ensuring strong return on investment even if the experience provided marginal results. Once built, most flight simulators greatly reduced operating costs and significantly improved knowledge and skills of pilots. The fidelity of flight simulations improves as development and sustainability become increasingly affordable.

Classroom instruction has its limitations. Traditional classrooms that include real-world learning experiences, problem-based learning practices, and/or high-impact practices have led to significant improvements in both student performance and satisfaction (Lunce, 2006). Successful education simulations tend to simplify real-world situations and scaffold student interactions to improve learning. Education games, on the other hand, are not usually built upon the logic of reality, although they may improve learning in the same way as simulations by having students systematically apply knowledge, practice skills, participate in events that elevate emotional attachment to learning, and increase social interaction (Hofstede, Caluwe, & Peters, 2010). Simulation games refer to the activities that logically represent reality, but provide a competitive component to further learner motivation. The fidelity of emerging technology is greatly improving. Thus, the gaps between the context within which a person learns and the context in which they will actually perform or apply what they have learned are cognitively decreasing.

In addition to bridging gaps between learning and performance contexts, simulations improve learning efficiency, intrinsic motivation, and transfer as learners experience phenomena that otherwise would be too dangerous, expensive, or impossible in the real world (Lunce, 2006).

Examples of Successful Simulations in Learning

Flight simulations are probably the most obvious example of how and why simulations work. Flight simulators provide pilots hands-on experience, prepare pilots for emergencies, and ensure pilots master the knowledge necessary to navigate complex missions. Flight simulators are better for novice pilots than actual sorties because they allow the pilot to make mistakes and discover skills through learned experiences without endangering their lives. Flight simulators also allow pilots to practice emergency skills that otherwise could not be tested or evaluated. Flight simulations complement classroom instruction when used to reinforce learning objectives, situate learning context, increase student interaction, and provide immediate feedback. The challenge for educators to adapt simulations has been justifying return on investment. Modeling and digitizing Mother Nature with high fidelity has been astronomically expensive. Educators should tighten their seat belts in the next decade as high-fidelity modeling and animation software becomes as affordable as computer monitors and disk drives. Take a trip to Sporty's Pilot Shop to purchase Saitek Flight Simulators for just \$300 (<http://www.sportys.com/PilotShop/category/989?gclid=CLOYmp63mawCFQZThwodvmf dPQ>).

The incredibly high fidelity of Saitek or Microsoft Flight Simulator X was not even possible just 10 years ago. These systems are now primary learning packages for commercial and military pilots. Flight simulations cannot replace the necessity of some real flight time, but they have significantly reduced the number of sorties it takes to qualify pilots at every level. Just think if our organizational managers and leaders had a similar system for practicing their skills before taking the controls at a real organization.

Celemi is an industry leader in business simulations. They have helped thousands of executives, managers, and employees gain new insights and achieve deeper levels of understanding of their businesses through simulations. They have developed detailed interactive learning spaces that simulate real-world context in finance, strategic management, competitive advantage, leadership, sales, marketing and branding, performance and motivation, and customer management. (You can view these artifacts at <http://www.celemi.com/What-we-do/Business-Simulations/index.php>). The simulations appear to leverage interactive physical learning spaces with interactive data management software. Utilizing digital media to process simulation data rapidly enables the simulation to compress time and provide immediate feedback to participants. Combining physical workspaces and interactive simulation software appears to provide a seamless, highly motivating, team-building environment within a highly interactive real-world experience in which learners can test their ideas and experience failure and success without affecting real organizational outcomes. If it is affordable and truly improves academic outcomes, then every business school in the world ought to leverage this type of learning environment, just as almost every flight training school leverages flight simulations. (<http://www.youtube.com/watch?v=KP2AJM4qSxM&feature=related> is a link to a summary video of Celemi innovations.)

In a different industry, the Advanced Disaster Management Simulator provides emergency managers and first responders an emotional learning experience that truly tests behaviors and knowledge in real-world context (<http://www.youtube.com/watch?v=hSnplEaA26k>). Situated learning improves critical thinking, decision making, and timeliness of response to chemical, industrial, natural, and terrorist scenarios. The simulation software enables a high level of complexity and authentic virtual context that better prepares responders for real-world events. The combination of video, audio, and scenario cues provide high fidelity. Participants interact directly with the virtual reality simulation software through audio and digital inputs. Participants commented that repeated attempts at the same scenario were beneficial in better understanding the necessity for making key decisions earlier. The trend toward even higher fidelity will undoubtedly continue.

Industry Masters, Tycoon Systems Business Simulation for Executive Training is a real-time business simulation designed to improve strategy, investment, finance, and entrepreneurial skills, teamwork, accounting, economics, industry, marketing, sales, and management decisions. This simulation is web-server based, has no software installations, can be used anywhere and at any time, is available in multiple languages, and has a low cost of ownership (<http://www.youtube.com/watch?v=-NJOEzAKfE0>).

Virtual Leader is a virtual simulator that challenges leaders to identify situational factors correctly and apply appropriate leadership skills based on learned leadership and management models. The animation is still choppy and the data fields are elementary; however, Virtual Leader is an example of how contextualized virtual models may be leveraged to reinforce academic learning in either synchronous or asynchronous environments. The example shows the complexity and progress in developing the animated nonverbal communication that is so important to the social sciences (<http://www.youtube.com/watch?v=ZMlddydz2QE&feature=related>).

In addition to emerging commercial learning simulations, the Department of Defense (DoD) is investing heavily in leveraging simulations to achieve training efficiencies. Several successful learning and training simulations are showcased at the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC). The trends of these showcases have moved away from flight simulators toward education and training of many other career paths and tasks as the cost of simulation development continues to plummet. Development costs are decreasing as high-fidelity software development platforms become more robust and plentiful. Boarders Ahoy is a three-dimensional (3D) simulation focused on a North Atlantic Treaty Organization (NATO) maritime interdiction built by ECS (<http://www.youtube.com/ntsatoday#p/c/D5B385E012C42D79>). The simulation is provided to online students located in multiple nations before they attend formal schooling.

Alelo uses modeling and simulation products for cultural awareness training. These simulations focus on nonverbal and verbal customs and courtesies. Virtual character animation is still choppy and not completely lifelike, but the programming does show the trend toward higher fidelity in a social context with resounding results (<http://www.youtube.com/ntsatoday#p/c/D5B385E012C42D79>). Alelo simulations are also compatible with mobile devices, increasing the range of deliverable mediums. The DoD's investment in human intelligence and improving the way in which its members interact globally is resulting in the development and successful implementation of numerous learning simulations.

The future of simulations for some institutions is to integrate them into a metaverse. Numerous corporations, government agencies, and universities are actively exploring and integrating simulations in virtual worlds. IBM, for example, created Lotus Connections in Second Life as a place for employees to work and interact in teams to solve real-world problems (<http://www.youtube.com/watch?v=Hj5RFGPbnl8>). Web 2.0 social computing designs such as Second Life are building communities of practice and communities of learners together to solve problems. Virtual worlds have amazing potential and tremendous momentum to gain fidelity. Avatars are participant personas reflected in virtual worlds. More than 21.3 million user accounts were registered in Second Life as of November 2010 (http://en.wikipedia.org/wiki/Second_Life). Air University constructed MyBase in Second Life and has been exploring embedding flight simulator mechanisms within the context of a virtual flight line on a simulated Air Force base. The vision is to improve fidelity of the simulations continually until they have real value in the education and training of DoD

personnel. Duke University has set a terrific pace at incorporating their metaverse campus into their overall education strategy. They have successfully embedded medical simulations into virtual hospitals and emergency rooms to allow students to apply nursing course knowledge (<http://www.youtube.com/watch?v=sL3D-59MbnY&NR=1>). These simulation and metaverse examples are a small sample of the emerging trend to leverage these incredible technologies into education and training. It is not a matter of *if* simulations will be incorporated into every academic course; it is a matter of *when* it will become reasonable to do so. As with most emerging technologies, early adopters will gain a considerable competitive advantage. However, educators should stay true to fundamental instructional systems design as they explore the software development process, and they ought to practice fundamental organizational change management skills as they integrate innovations.

Natural Resistance to Simulation Development and Integration

Kinicki and Kreitner (2009) present several factors as to why individuals may be resistant to integrating virtual simulations into their educational and training environments. An individual's natural predisposition to resist change, fear of the unknown, mistrust, fear of failure, loss of status or job security, peer pressure, disruption of cultural traditions, lack of tact or poor timing, nonreinforcing reward systems, and past successes or failures constitute fundamental reasons educators and trainers will resist educational and training innovation. Planning for every innovation should consider these factors. Champions of integration need to consider integration strategies carefully from the very beginning of the simulation planning process. Integrators who demand proof that learning will be improved or a detailed cost/benefit analysis will be disappointed. The creativity necessary to adapt to integrating emerging technologies suggests that no one has carefully developed and evaluated the technology as initially envisioned. Benefits will be much harder to negotiate than the obvious costs. Additionally, the high costs to develop high-fidelity pilot projects often prevent stakeholders from loosening the purse strings. Evidence suggests that early adopters are taking the plunge with mixed results, while those waiting for proof are on the losing end of the knowledge gap.

A widening gap between public cognition and private artifacts is growing. Burbules and Callister's (2000) study revealed a concern regarding the widening gap between skills, attitudes, dispositions, and technical access. This widening gap reinforces many of the resistance factors, resulting in strong emotional resistance to the integration of emerging digital simulations in traditional education and training environments. Most executives

require detailed and significant positive cost/benefit prospects that do not exist, and educators require proof that the new methods are significantly better than the current ones. However, the results needed to convince them will not be realized until after they accept the investment risk necessary to develop the innovations appropriately.

At a deeper philosophical level, integration teams may want to consider organizational learning tactics and leverage the language of technological determinism (Pannabecker, 1991). Technological determinism describes the paradigm that a sequence of previous adaptations to new conditions and events determine our methods and tools for accomplishing tasks. These adaptations, in retrospect, are regular and predictable. In short, technology is determined to develop new methods, and adaptation to the new technology is predictable. Pannabecker suggests removing the criteria for technology to produce significantly different results, and instead adapt to new technologies as how things will be accomplished in the future (1991). Achieving this level of understanding with defiant faculty and staff is clearly an enormous challenge that may doom early innovators before they ever really begin. I find it interesting how librarians first resisted Al Gore's call to leverage the Internet and create online libraries (Hunter, 2003). Today, the stacks are headed toward high-tech storage and retrieval systems, if they are not extinct. Many educators are calling for a similar paradigm shift in their classrooms to prepare our youth for society's new set of rules (Shantz & Rideout, 2003).

Cognitive and artifact innovations developed since the 19th century are staggering. Modern technology is the first limitless technology (Davis, 1981). Techniques have formed to develop artifacts of computation that are infinite in process abilities and, therefore, infinite in application, enabling its user to be creative and to create a personal identity using the artifact (Mark, 1999). Computers and the Internet provide techniques for controlling our environment by providing information, computation, presentation, and communication. Computer simulations inherently have flaws and inefficiencies because they are, in the end, fictional representations. We are likely to strive now for faster and more meaningful ways of interacting and seeking information, processing, and computing in our endeavor to improve our sense of control over our environment.

Microcomputers, sensors, and microelectronics have begun to permeate every facet of our environment. The invasion of pervasive computations has required the development of secure, ubiquitous communications networks that enable complete access to the growing capabilities of the Internet and global communications networks from anywhere and at any time. Mobile communication and the Internet continue to converge in a mobile computing infrastructure. The National Institute of Standards and Technology (NIST), a nonregulatory agency of the United States Department of Commerce, released the Federal Cloud Computing Strategy in February 2011. The significance is that cloud computing expands the pervasive nature of digital mediums exponentially. The role of NIST is to advance standards and to collaborate with government, industry, agency, and international stakeholders in the pursuit of innovation, trade, security, and jobs. More than a billion dollars a year is being funneled to support technological innovations. The first sentence of NIST's 2011 budget report states the belief that "A constant flow of new technologies is the bedrock of a

healthy, growing economy” (NIST, 2011). Although the U.S. government has undergone significant budget cuts for the fiscal year 2012, NIST has significantly expanded its budget year after year. Current trends toward even higher-fidelity video/audio, animation, and complex simulation modeling and the increasingly pervasive mobile applications of technologies will only accelerate in the future. High-fidelity simulations will soon become a common and expected way of learning. Those who do not innovate risk teaching and evaluating calculus with a slide rule. Implementation of new innovations inherently brings a whole new list of challenges that will only be solvable by highly specialized disciplines (Burbules & Callister, 2000). Educators and trainers know this and likely fear that they will no longer be relevant in the new specialized disciplines.

Emerging Web 2.1 metaverses are reinventing the Internet into 3D spaces in which individuals can interact in both synchronous and asynchronous mediums. Metaverses are fictional spaces, even though many developers are going to great lengths to model real spaces. Educators want to know whether simulations embedded in a metaverse can generate situational learning benefits. I recently heard respected educators debate whether metaverses were real or unreal and therefore contribute to or bastardize real-world learning outcomes. We do know that the benefits of carefully crafted simulations are real. Very few studies identify how learning from a metaverse is better or worse than other mediums.

SmallWorlds, Entropia Universe, IMVU, Active Worlds, Second Life, Twinity, Smeet, and Meez are emerging metaverses with various potential to simulate situations. New metaverses are emerging every month. The potential for a university to develop its own metaverse is high. The cost of developing its own proprietary development platform is also high, especially when many executives demand pilot studies to prove concepts and justify expenditures. The path of least resistance, and perhaps least persuasiveness, is to develop submetaverses on commercial platforms to test learning concepts. In the long run, the multitude of metaverses will be renamed metagalaxies and interconnect as a single metaverse. The toughest sell to educators seems to be that future society will fully integrate augmented reality and virtual reality into every person’s being. Simulations, fictional by definition, will be constructed and delivered in virtual reality. Today, we are only just starting on this adventure.

This description provides a basis for creating reasonable communications with educators who may resist the integration of new technologies into educational environments. Education and communication, participation and involvement, facilitation and support, and negotiation and agreement are all strategies for unfreezing an organization. I believe real change takes time, so change agents should be patient and persistent as they create momentum throughout an organization to adopt emerging technologies. Change agents should demonstrate that the new technologies are compatible with their existing organizational values, that new technologies are not too complex, and that the new technologies can be modified and improved upon over time. Change agents that apply shared power strategies such as employing an advisory committee, should appear genuine and sincere in fielding the committee’s concerns. Champions of change must not appear to be self-serving, have a high emotional stake in the process, or be isolated from those who

will be required to implement the changes (Schermerhorn, Hunt, Osborn, & Uhl-Bien, 2010). Change management strategy suggests that educators should use a simple, logical process for integrating new technologies as part of their courses. The instructional systems design process, a process that most serious educators are very familiar with, can be combined with the software development process to provide a clear road map toward meaningful integration of emerging technologies in such a way that most educators will immediately feel connected to the course improvement process.

Instructional Systems Design

Several models for developing meaningful instruction exist. Dick, Carey, and Carey (2001; see their Figure 1) provide a traditional instructional design process that helps educators align instructional goals to outcomes. Educators who desire to integrate new technologies will find immediate support from those who realize the benefits of applying the instructional systems design (ISD) process to improve their courses. Revising instruction is a critical step that empowers educators to adapt to emerging learning technologies. Revising instruction requires instructional developers to return to early steps in the creation of instruction. The ISD process suggests instructional designers periodically reanalyze performance objectives, assessment, instructional strategy, instructional materials, and formative evaluation. I would even suggest that instructional designers review instructional goals periodically to ensure that emerging technologies have not provided new opportunities to incorporate additional or modified goals seamlessly. The first step to revising courses is to reevaluate instructional goals and performance objectives. Instructional systems design is an effective tool for unfreezing course designers.

Instructional goals and performance objectives may or may not change when adopting new technologies. However, simulations have classically revolutionized student performance metrics, the rate of feedback, the materials used, and evaluation of learning. Limitless computational and display capabilities characteristic of modern technologies explain a widening gap between early adopters and traditional educators in these areas that develop and test learning rate and depth. Software can immediately assess every keystroke or mouse movement, for example, and provide immediate feedback to the student on situational appropriateness.

The immediate action–response cycle generated by new technology is revolutionizing learning. Action–assessment–simulated response–revised action cycles occur much more quickly in simulated environments than they usually do in classroom or in real settings. Simulations also motivate learning through precision reinforcement. Precision reinforcement is the application of a consequence that accurately reflects the assessment of the learner’s input and the intended input. Constructive learning environments may aim to

maximize precision reinforcement in rapid action–response cycles to shape applied learning outcomes over time. These may sound like the same aims as traditional education; however, the context of time between classroom instruction and simulation is radically different.

Traditional learning usually involves reading a chunk of information and attempting some reflection problems. The next day, while in class, the student may listen to an instructor reinforce the major concepts of the readings. Two weeks later, a test may be given to determine whether the student has remembered the knowledge or has recently reviewed the information and has the concepts in short-term memory. The student will likely not review that knowledge after the test unless it is repeated in a class that provides more depth. Most knowledge that students attain is not assessed in application, and the feedback loop is completed perhaps once or twice over a course of days and weeks. On the contrary, simulations can situate and assess the required knowledge and provide immediate feedback of correct application and understanding in milliseconds. Simulations can also provide precision reinforcement based on what it has calculated to be true of the learner's motivations. The application of precision reinforcement, rate of assessment, need for fidelity, and artifacts of the simulated learning environment are mediated by integrating ISD with the simulation design/development model (SDDM).

Simulation Design/Development Model

Educators interested in developing simulations need to understand how software designers and developers operate. The most basic software development model may be used. The SDDM captures the most critical steps in software development (Figure 2). Initial planning and planning phases will be required to produce the detailed simulation requirements necessary for simulation developers to produce exactly what educators envision. Developers will have the laborious task of transferring design requests to the digitized environment once they capture the requirements. Each simulation component needs to be tested and evaluated before it is deployed. Educators will need to decide whether the simulations are ready to deploy, require rework, or require additional designing/development before deploying. A single component of a simulation may be cycled through the model numerous times before deploying. The number of times a simulation cycles through the model largely depends on the level of detail captured in the requirements and initial design analysis, as well as the programming abilities of the developers. High fidelity often requires more initial development time and more cycles through the model, leading to higher costs. Reflecting on personal experiences, the best development resulted when both ISD and SDDM were integrated.

Figure **[Figure 2]**

Instructional Simulation Design and Development Process Model

The instructional simulation design and development process model (ISDDPM) integrates the instruction design process and the software development process (Figure 3). The integrated model provides a strong foundation for guiding instructional simulation design and development projects. Each step of the SDDM contains ISD steps. Each phase of the ISSDPM becomes a significant project milestone. Formative/summative evaluations are both a completion point and a beginning point, as indicated in the ISD process model.

Figure **[FIGURE 3]**

The length of each step of the ISDDPM is dependent upon the complexity of the design and the size of the group involved. Planning, requirements, design analysis, and testing/evaluation teams are best kept between five to nine members. These members may be the same members who constitute the advisory committee. Members should be cross-functional and play critical roles in developer selection and deployment of the simulations.

Initial planning begins with a vision or desire to integrate emerging technologies into instructional methods. Initial planning should take place with key stakeholders of the instruction, its delivery, assessment, and institutional strategy. One goal of initial planning may be to unfreeze stakeholders and establish group cohesiveness. Design goals, limitations, organizational goals, and instructional goals should be discussed and aligned. Now is the time to find out whether the vision for integrating emerging technology is not aligned with organizational goals and resources.

Context analysis can be achieved by evaluating how instruction is currently delivered, how the knowledge will actually be applied, and discussing how a simulation may help bridge the contextual gap between where and how knowledge and skills are learned versus how and when they are performed in the real world.

These discussions and a realistic discussion of organizational resources that may support the project should provide enough data to develop an initial simulation grand strategy. If few resources are available, then the preplanning group may want to consider a pilot project first. However, stakeholders should realize that the cost per student would be considerably higher if the design only serves a small population than if designed more robustly. Pilot projects must be robust enough to provide reasonable results. Cost/benefit models are often skewed toward high costs for pilot projects. Modular development of

separate simulation capabilities may be possible if the learning objectives are not completely interdependent upon each other.

Modular development may also be considered if each module relies on the results or development of the previous module. A total project may be considered if resources will be available to support a more robust development schedule. A timeline should also be discussed for each module and for the total project. Costs of the project are a function of scope, fidelity, and development cycle time.

Return on investment and cost/benefit discussions should not be a cornerstone at this point in the process. Some members of the team may benefit from a general discussion of the benefit of simulations in learning environments and an overview of simulation capabilities. However, early in the process, costs are much easier to define than benefits that have not yet been planned, developed, or evaluated. Many projects can be sidelined early if the discussion requires an immediate cost/benefit analysis before proceeding to planning and requirements.

Another discussion point that may occur in preplanning is for the team to appoint a project manager to help keep the project moving forward. New initiatives are often low on the daily priority lists of most educators and executives, although they may be the most important in terms of achieving long-term goals. A project manager will have the primary responsibility of keeping the team moving through the ISDDPM at a rate that fits organizational culture and needs.

The planning phase launches from the initial grand strategy and instructional goals outlined in the preplanning seminar and moves toward specific learning objectives and how a simulation may be a good instructional delivery, assessment, and instructional strategy. At least one planning seminar should be held for each module that is to be developed. The planning seminar will further define the instructional and learning goals that may be achieved through simulation. The planning team should review the learner and context analysis conducted in the preplanning seminar. The context for the content of each simulation module should be discussed to ensure the simulation creation helps bridge the learning/performance context gap. An instructional strategy should emerge as team members envision and begin to create the details of how a simulation can augment the delivery and assessment of the instructional content. Team members should clearly articulate the simulation outcomes and the level at which learning should occur. Student performance data necessary to establish a baseline comparison at the end of the process may also be important to stakeholders. The planning seminar should discuss what kinds of data might be important when assessing the effects of the simulation on learning. These data are often required to continue and expand the resourcing of additional modules and technological integrations.

The next step of the ISDDPM is requirements. Requirements are the specific features of the simulation that are critical to articulate to developers. Requirements include environmental factors, artifacts, context, interaction, input/response, data collection, feedback, reports, and controls. Often, the requirements of simulations and interactive

models require a storyboard to linearly link inputs to outputs and to identify random response generators. Requirements transfer instructional designs into simulation designs. Requirements seminars are often very lengthy meetings with developers. The developer will need to have an accurate shared vision of the simulation from beginning to end. These seminars are often difficult for faculty, who do not understand the demands of programming, and programmers, who do not understand the content of the instruction. Requirements sessions are often broken down to specific subsets of the simulation design to help the developers design more accurate simulation components. Later, the subcomponents of the simulation are linked together.

Subject matter experts (SMEs), simulation design visionaries, and developers are the primary players in establishing simulation requirements. Requirements seminars may be held without developers initially, to develop a more detailed statement of work that may be used to source a simulation developer. However, once the requirements teams have captured the most accurate statement of work possible, they should solicit proposals for the development and make a selection. The developer selected should be able to demonstrate capabilities to develop the appropriate fidelity for an appropriate fee and in the appropriate amount of time. Fidelity and development time are the negotiating factors that tend to drive cost. Developers will engage much more quickly with clients who have already completed strong planning and requirements seminars.

Additional consideration should be given to developer architecture capabilities and to any hardware architecture upgrades that will be necessary to run the intended simulations. Architecture capabilities should be fully developed and priced during requirements. Wireless conductivity, upgraded processing speeds, broadband Internet access, upgraded graphics cards, additional devices, specialized displays, projectors, etc., need to be sourced, priced, and purchased. The project manager should be able to time the purchase of hardware just in time for the deployment of the simulation. A disconnect between architecture and software means enormous frustrations and inefficiencies in the future.

The developers will continue to mature their design as captured by the requirements until they are comfortable that they can begin programming. The analysis and design phase of the ISDDPM continues the process of refining requirements and transferring the requirements into programmable code. Developers often demonstrate prototype artifacts and segments during this phase to show simulation capabilities and clarify requirements. The clients should require a complete module design plan from the developers before allowing them to proceed to full development.

Once developers have captured the requirements and have an approved design, they will begin developing meaningful segments of the simulation. Most developers will begin by building the contextual environments of the simulation, followed by the action/animated portions. During the module development phase of the ISDDPM, SMEs work routinely with developers. The complexity of the designs and the resource capabilities of the developers will determine the length of the analysis and design phase.

During module development, the implementation team should have time to create a detailed simulation integration plan. Lack of an integration plan may result in poor reception by affected faculty, students, or rejection by stakeholders or institutional information technology specialists. Careful consideration of these groups was important during planning, but they may have forgotten the content of those early preplanning meetings. The advisory committee is best able to make careful change management considerations. I have seen fantastic technologies erode without use because effective change management was not used.

Implementation plans should consider how the new technologies would be delivered and integrated into the current information technology environment. They should also consider who, when, and how to unfreeze the organization. Advisory committees should consider developing faculty and student education and training on how to get the most out of the new technologies and how to make recommendations for improvements. Additionally, implementation plans should consider if and how the new simulations will be evaluated as a complementary or replacement instructional medium. Finally, the implementation plan should have a detailed timeline for deploying the new technologies and for refreezing the organization after successfully incorporating the technologies.

Once a module has been developed, it needs to be tested and evaluated. Beta-testing new technologies is critical in providing feedback to developers so they may refine their products. The advisory team and SMEs should test and evaluate every portion of the simulation to ensure it has been developed according to specifications and design intent. Further, SMEs must consider if what has been created meets the intended learning objectives. If not, then go back to redesign. Students' and faculty's first experience with the new technology is critical to its successful implementation. I highly recommend not deploying anything that is not meaningful and user friendly. Many pilot studies will first deploy the new technology to an experimental group for summative evaluation and to provide data for the much debated cost/benefit analyses to executives.

The final phase of the ISDDPM is the formative and summative evaluation stage. This phase requires the construction of surveys, observation, pilot study results, and posttests to validate the effectiveness of the new technology. The advisory committee may construct many of these data collection tools during module development. If designed and developed appropriately, the simulation should be a satisfying, motivating experience that deepens learning in a performance-like context. However, often during change processes, initial resistance decreases satisfaction.

Summary of Recommendations for Early Adopters

The following is a summary of my recommendations for faculty who are integrating new technologies into their courses.

- Use the ISD model.
- Use a software development process model.
- Draft a self-managed, cross-functional advisory team.
- Help the organization understand technological determinism.
- Thoroughly employ organizational change strategies.
- Incorporate resistors into the preplanning process.
- Incorporate the most creative team members into the planning process.
- Consider integrating assessment into the new method early in the design process.

Use the ISD model. Building a simulation for educational purposes clearly is a manipulation of the instructional design process. Before incorporating a simulation, stakeholders should consider the most appropriate method to deliver and evaluate each instructional goal and objective while considering the abilities and interests of faculty and students. Simulations are not the most appropriate delivery methods for every learning objective.

Use a software development process model. Software developers will gladly share horror stories about clients who had no idea what they wanted or how it was going to work. They somehow expected programmers to be masters of the content when, in reality, they are masters of program engines. If clients clearly articulate what they want, then programmers can usually achieve fidelity. Clients who change requirements during and after development drive up costs exponentially, cause project delays, and cause stakeholders to become frustrated.

Draft a self-managed cross-functional advisory team/council/committee. Self-managed cross-functional teams are more likely to consider the second- and third-order effects that make implementing new technologies challenging. Cross-functional teams are also likely to prevent groupthink, present more creative solutions to project challenges, and vocalize resistance to change efforts. The advisory committee can determine how to best deal with those challenges in a small group and expand their solutions to the rest of the organization.

Help the organization understand technological determinism. Most executives are frugal with their operating budgets and require strong cost/benefit analyses that fully support their decisions. The accounting culture contradicts the philosophical basis of technological evolution. It is difficult to discuss benefits when the tools for creating benefits have not yet been created. Stakeholders should understand the philosophy of technology

determinism to soften their resistance to become an early adopter of emerging technologies. However, early adopters will continually pay a premium for differentiating with technology.

Employ organizational change management. Integrating new technologies into academics and training is a significant change for faculty, staff, and students. Organizations that are precise with change management actions are more likely to gain greater results with their integrated technologies than those organizations that leave change management to chance.

Incorporate resisters into the preplanning process. The best time to understand resistance to incorporating new technologies is in the beginning, during preplanning. Factors for resisting new technologies should be captured and addressed before moving beyond the planning phase. Some resistance may still exist, but the advisory committee should have a keen sense of factors that need to be incorporated into the implementation plan. Effective leadership is required for effective organizational change.

Incorporate the most creative team members into the planning process. Creating a metaverse and developing simulations require creativity. Members without much creativity may spend plenty of money for little added capability, whereas highly creative individuals are more likely to generate revolutionary ways of achieving the objectives utilizing innovative technologies. Better to be too creative and have to tone it down due to cost or scope versus paying for one step forward although the technology exists to leap four steps forward for the same price.

Consider assessment strategies early in the design process. Computers assess inputs and gather, organize, and report data. That is what they do best. Assessment can be integrated directly into a simulation so that the feedback loop is completed at an extremely high rate of speed and accuracy. Assessment should be integrated with delivery when integrating new technologies to learning environments.

Trends in emerging technologies suggest that human animation, graphics fidelity, situational models, and assessment scenarios are maturing and becoming more affordable. The opportunity and demand to integrate digital simulations into constructive learning environments will continually strengthen. Those who leverage sound ISD and are prepared to manage software development projects may be best positioned to integrate the full potential of these limitless simulation innovations successfully.

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Figure 1

Instructional Systems Design (ISD) Process: The Dick, Carey, and Carey (2001) ISD Model. This Figure Demonstrates Continually Reviewing Instructional Delivery Methods and Incorporating New Technologies as an Integrated Responsibility for Instructional Designers.

Figure 2

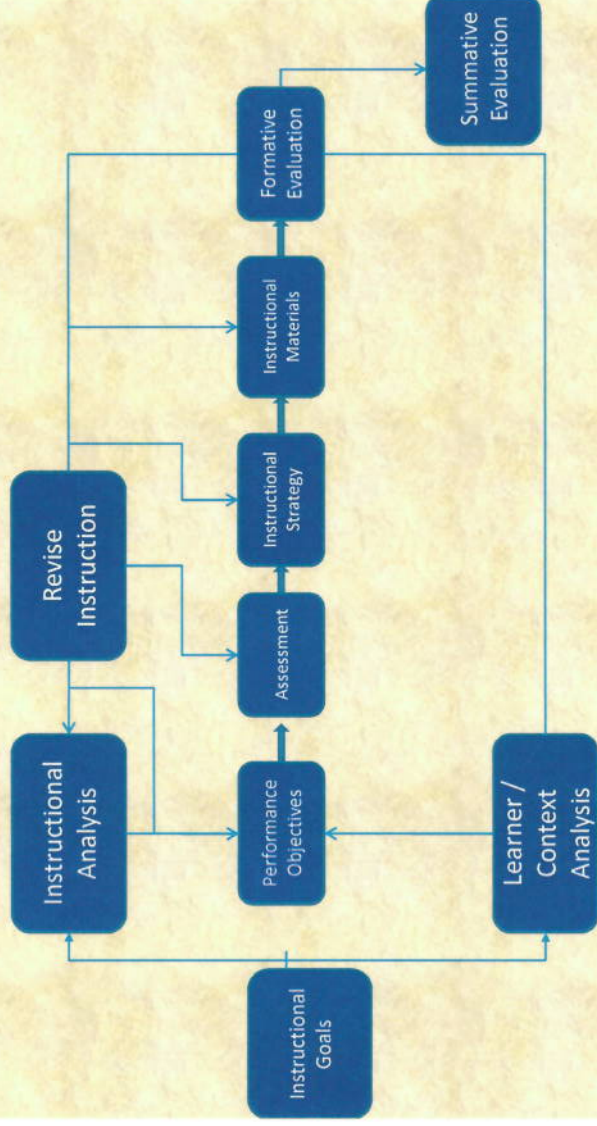
Simulation Design/Development Model. This Model May Be Used in Concert With the Instructional Design Process Model to Help Manage the Design, Development, and Evaluation of Educational Simulations.

Figure 3

Instructional Simulation Design and Development Process Model (ISDDPM).

The ISDDPM Integrates the Instructional Systems Design and the Simulation Design and Development Process Models Into a Single Road Map.

Instructional Systems Design Process



Dick, Carey, Carey ISD Model

Fig. 1

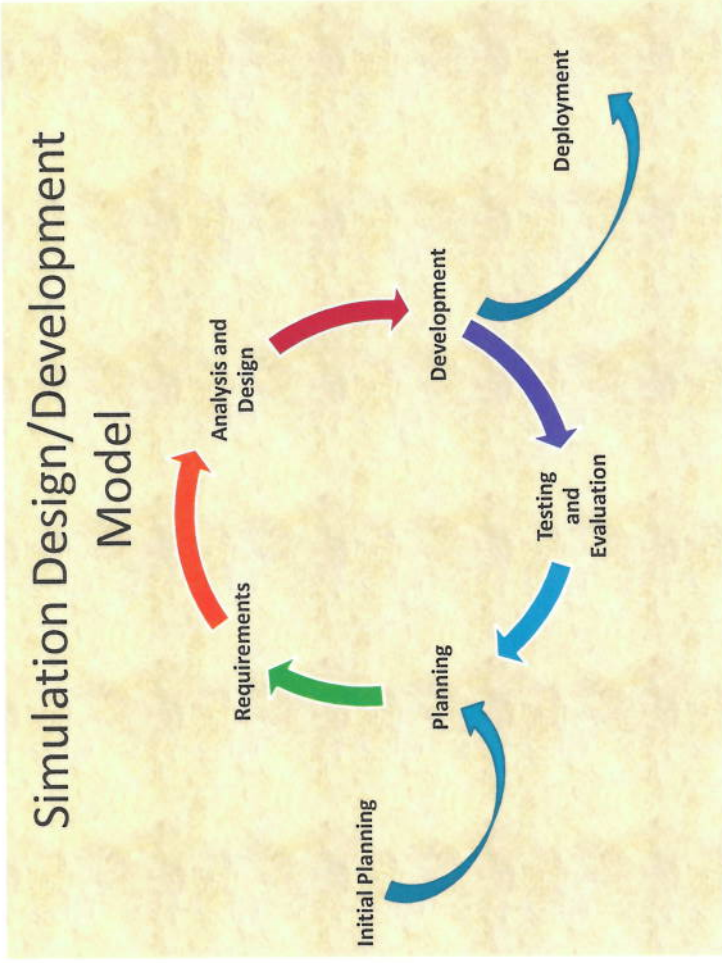


Fig. 2

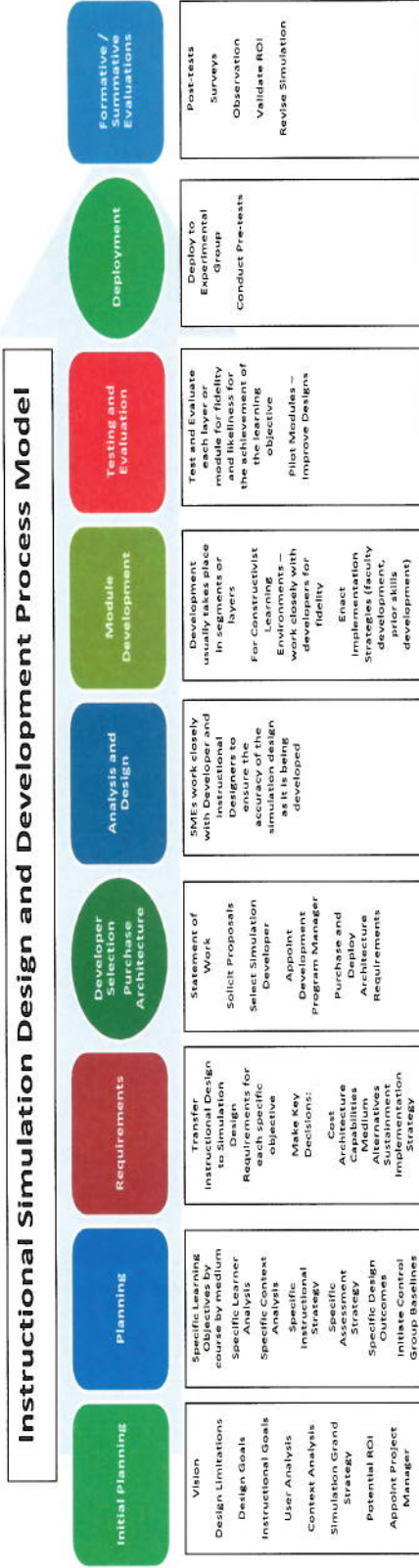


Fig. 3