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Alternate Reality Games in the Systems Engineering Classroom

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Abstract. What can systems engineers learn from playing a game? As part of a liberal arts and engineering collaborative grant, game designers were recruited to create an Alternate Reality Game (ARG) to be played as an educational activity in a systems engineering course. The purpose of the ARG was to get students to think more deeply about "the diversity of the human in the loop," or how every best laid engineering plan must take into account the uncertainty of human responses and how they will interact within their system. This paper envisions the classroom as a community and discusses the design process of creating an ARG for a college classroom and the interdisciplinary collaboration that such a process requires.

Alternate Reality Games in the Classroom

Alternate Reality Games, or ARGs, are a combination of online and offline puzzles, challenges, and narratives that blur the game world with players' real-world lived experiences. A frequent mantra for ARG players is *this is not a game* (Jagoda, 2013). Within a game's play space or "magic circle," fantasy elements allow players the thrill of fear while the knowledge that the game is an artificial system protects players from real consequence (Laurel, 1993). The use of games, including ARGs, in the classroom is a current pedagogical media trend, but games scholars such as Tracy Fullerton have questioned games' efficacy in the classroom (2014). Is the difficulty of making games work in classroom settings because games are at cross purposes to traditional classroom structures? College classrooms operate with syllabi and expectations delivered up front, whereas often the fun of playing a game is in discovery; indeed, discovery is a critical type of work involved in play (McGonigal, 2011). Similarly, many games' designs are purposefully inefficient (Fullerton, 2014), requiring that players learn through exploration - including through dead-ends and do-overs.

The idea of games as fully academic and simultaneously fully exploratory and fun seems paradoxical.

However, scenario or simulation-based learning, which bears much in common with ARGs, is not new to Systems Engineering. This approach has been used in Systems Engineering to develop a pedagogical framework for "a holistic approach that compels trainees to apply, interactively, systems engineering, and project management tools in one environment (project)" (Cohen, Iluz, and Shtub, 2012).

Additionally, dramatic, alternate reality, or "mixed-reality" (involving digital and live interactions) scenario-based learning in other disciplines has shown promise in improving student group dynamics and student's valuation of humanistic skills. Live simulation scenario-based learning has been indicated to improve the quality of team behavior in crisis training (Shapiro et. al., 2004).

Additionally, a study by Koponen, Pyörälä, and Isotalus "revealed that medical students' (n = 129) positive attitudes to learning communication skills improved significantly (Wilcoxon's test, z = −3.932, p = .000), and their negative attitudes diminished significantly (Wilcoxon's test, z = −3.677, p = .000)" with theatrical learning, including role-play and interactions with simulated patients (2014).

With these challenges and precedents in mind, the game designers created a classroom ARG, *T/ERROR*, for Worcester Polytechnic Institute Systems Engineering class SYS 501 taught by Dr. Shamsnaz Virani. SYS 501 is an introductory graduate Systems Engineering class that serves as "an introduction and overview of the methods and disciplines that systems engineers use to define, develop, and deploy systems. It includes specific integrated examples, projects, and team building exercises to aid in understanding and appreciating fundamental principles" according to the class listing. This classroom ARG aimed to use engineering students' preconceived notions about social structures and stereotypes about college life to reveal flaws in their design planning process and systems conception.

Initially, the *T/ERROR* ARG presented language and scenarios typical of a general campus security threat, only later to reveal that the attack was actually one of gender-based violence. This "twist" was designed to draw the primarily male student base out of typical modes of thinking as well as to highlight considerations usually supposed to be externalities, such as gender, as being in fact critical to understanding the system. This paper discusses the utility of game-based pedagogy and uses this ARG as a case study for analysis on which aspects of the play experience were successful, which were unsuccessful, and what the designers would do differently in the future.

This approach to systems engineering education built from a foundation laid by Flushman, Gondree, & Peterson on the use of ARGs in Computer Science education to "help bridge concepts into the real world, drawing students into fictional scenarios presenting authentic problems" (2015). In particular, this ARG drew on the modular design, clearly-marked fiction, and emphasis on social interaction present in their work to help safely and coherently teach technical material while maintaining high student engagement. Finally, this ARG also employs traditionally game-like elements such as a clear sense of purpose, collaborative experiential learning, and systems of intrinsic motivation through narrative that also saw success with the ARG implemented by Flushman et. al.

Accelerating Experience in Systems Engineering Learning

Systems engineering is an experience-based discipline that demands practitioners are repeatedly exposed to realistic, emotionally engaging, integrated scenarios that enable learners to grow "scar tissue" instead of learning from observation (Squires et. al., 2011). In order to accelerate this lengthy systems engineering learning process, Squires et. al. proposes a classroom ARG approach that provides students concrete experience in realistic scenarios. Of particular emphasis in this work are the so-called "Aha moments" which foster the growth of "scar tissue" by requiring players to "re-examine assumptions when conditions have changed…[and] align with learning objectives." In the *T/ERROR* ARG fiction, the critical student assumption is that the human factor of gender dynamics is external to the system when in fact it is the major indicator of campus violence; students' realization of the importance of gender-motivated violence is the major "Aha moment" around which the ARG is built.

A secondary emphasis of the work of Squires et. al. is "reflective observation…facilitated by performance feedback… [which] then becomes the springboard for helping individuals engage in abstract conceptualization." This, along with work by Flushman et. al., shaped the ARG to include unexpected events (the "twist"), self-reflection, constant feedback, and emphasis on players' ability to generalize concrete experience to abstract knowledge. This generalization task applies both to discrete system engineering tasks as well as to how students think about sociocultural systems components.

Student deliverables (assignments) due during the ARG were designed to follow the systems engineering life cycle from initial system definition through detailed design work (Figure 1). Students worked from a general system concept to a granular level of detail over the course of the ARG as shown in the Decomposition and Definition workflow in Figure 1. This ensured that ARG deliverables adhere to an organized model of systems engineering thought and represented standard industry workflow.

However, due to the narrative structure of the ARG and the revision tasks required by students, the actual structure of classwork resembles the Decomposition and Definition workflow of Figure 2.

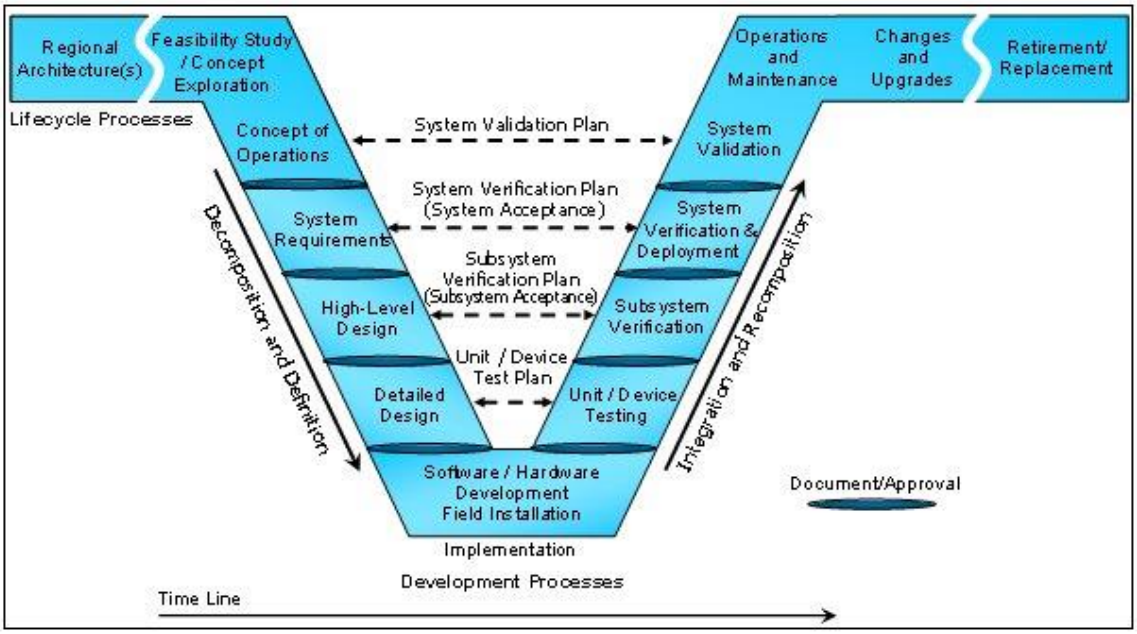

Figure 1. The systems engineering "V" model, depicting the systems engineering life cycle (Federal Highway Administration, 2013).

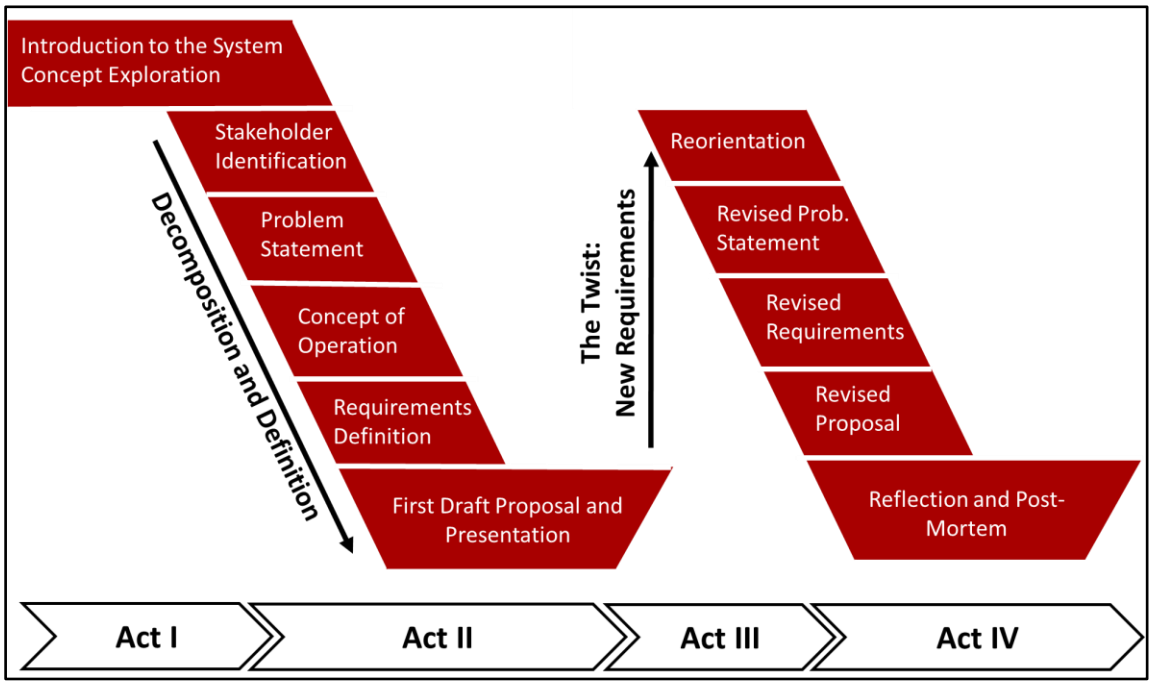

Figure 2. The adaption of the "V" model, above, for the *T/ERROR* ARG.

Designing a Compelling ARG Experience

Based on foundational research, this systems engineering ARG was designed around the following experience goals for students:

1. Performing systems analysis tasks in a realistic scenario
2. Revising prior work and prior assumptions according to evolving conditions
3. Considering aspects of systems often considered externalities, particularly gender dynamics and gender violence
4. High engagement and motivation via team competition dynamics and investment in the narrative

In addition to these guidelines, ARG designers followed a number of design goals:

1. Modularity: the ARG takes place in 4 acts of 2 hours each and can be delivered in as little as 30 minutes at a time
2. Low resource requirements: ARG materials and actor performances are the only resources needed in addition to class time and instructor time
3. Ease of implementation, maintenance, data collection, and reproduction
4. Realism of the scenario

To ensure the ARG narrative was as realistic as possible, the lead ARG designer interviewed the Chief of Campus Police at Worcester Polytechnic Institute. Additionally, whenever possible, real-world data was used to drive activities, such as the government mandated Annual Security and Fire Safety Report produced by the institution.

Finally, to further improve realism and student engagement, the ARG used live actors sourced from WPI faculty and graduate student groups.

ARG Implementation

The action of the ARG opened with a series of (in-fiction) violent attacks on WPI campus. Key stakeholders in the community asked students via website correspondence (made available on Canvas LMS digitally) to respond to this campus security threat by proposing changes to campus or community safety practices using their systems engineering knowledge. Students worked in groups of 3-5 to meet this call to action, with the key stakeholders, played by a game designer, were available for interaction at any time through email. After completion and presentation of their initial draft proposals, students were visited by actors portraying key stakeholders and informed that all the victims were women and the attacks were in fact gender-motivated, forcing students to confront their initial assumptions and rework their proposals accordingly.

This narrative was told through in-class handouts mocked up as local news stories as well as through online content residing in the Canvas LMS (Figure 3). The instructor was “in-fiction,” i.e. acted as though the ARG events were real, and helped guide students and disseminate ARG material. Traditional ARG elements such as social media were not used so as to reduce maintenance time and to clearly define the “magic circle” of the game as separate from reality.

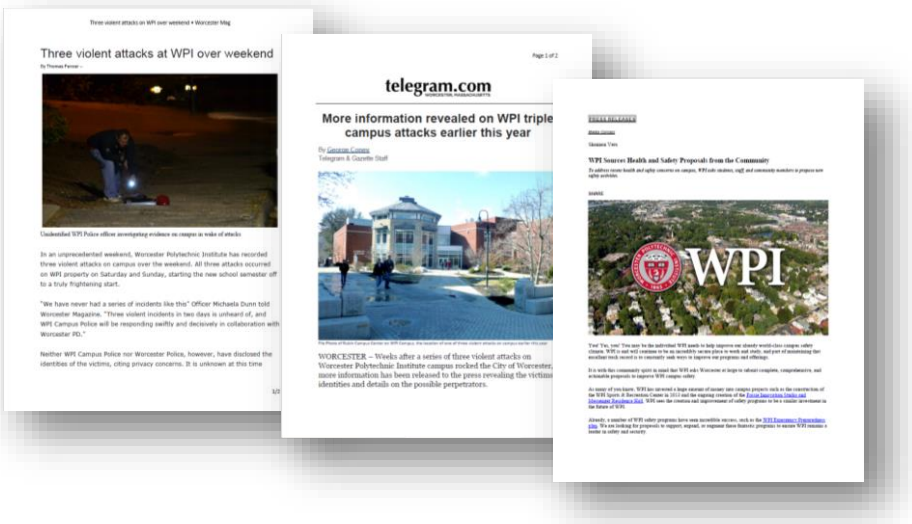

Figure 3. Actual materials used to tell the narrative of the *T/ERROR* ARG to SYS 501 students, including mocked up news articles and website printouts.

Actor Appearances

Three amateur actors were used to portray key stakeholders with different focuses (Table 1). Involving actors was extremely important to the fidelity of the ARG experience, not only to advance the narrative but also because "social interaction can be seen as fundamental to experiential learning" (Koponen, Pyörälä, and Isotalus, 2014).

Actors appeared in person once in class after student groups had presented their initial proposals, both to present the "twist" and to be available to help student groups revise their proposals based on professor feedback and new narrative information. Help given by the actors was based on instructor feedback and tailored to fit the characters, priorities and motivations to support the narrative as well as provide pertinent, practical academic assistance. Key feedback points from the actors during this appearance, based on the weaknesses of student work, were:

- Does the proposal address current weaknesses in campus security response rather than simply expand the current system?
- Are safety measures in the proposal appropriate to the physical environment in which they will be deployed – i.e. are devices sufficiently accessible and durable?
- Does the proposal address the specific concerns of one or more of the key stakeholders?

Characters were also available via email before and after in-person appearances, played by a game designer. This provided multiple touchpoints for students while keeping time demands on the actors low.

Table 1: Key stakeholders portrayed by actors.

Character Name	Job Title	Focus
Franklin Gray	Campus Police Security Task Force Leader	Campus security and policing
Shannon Vera	Campus Security Liaison to the President	Campus safety and public relations
Bartholomew Cohn	Community Protection NGO Founder	Community safety and security

ARG Narrative and Deliverables

The ARG used a 4-act structure in which each act represented a major phase in the systems engineering process and a major phase of the fiction (Table 2). Student deliverables were staged within these acts to fit naturally within the narrative structure and support the learning/experience goals of that act.

Table 2: The 4-Act ARG narrative structure.

Act	ARG Plot	Experience/Learning Goals
Act I	Premise and stakeholders (actors) introduced	Assess and define initial system
Act II	Additional security information provided	Develop system concept and perform foundational research, form and present a proposal
Act III	Actors appearances: actors reveal the "twist" and help student groups; students begin to revise	Perform deep research and react nimbly and comprehensively to new requirements
Act IV	Students continue to work in groups to revise their work, perform reflective analysis	Complete and present a revised proposal

In Act I, students learned that three violent attacks have occurred on WPI campus over a single weekend. Little was known about these attacks, but three community leaders (the key stakeholders) all had issued a call for proposals to the community at large to help address this security threat. Each stakeholder framed their request in terms of their perspectives and roles.

In Act II, students were given additional online resources such as WPI library links, links to Worcester community websites, official WPI Campus Emergency Guides (Figure 4), and official crime reports and statistics reported on in the WPI Annual Security and Fire Safety Report. Students were also given the email addresses of all three key stakeholders and encouraged to contact the characters with any questions (emails were answered by a game designer in character). During this time groups developed their first draft proposals and presented them in class to close Act II.

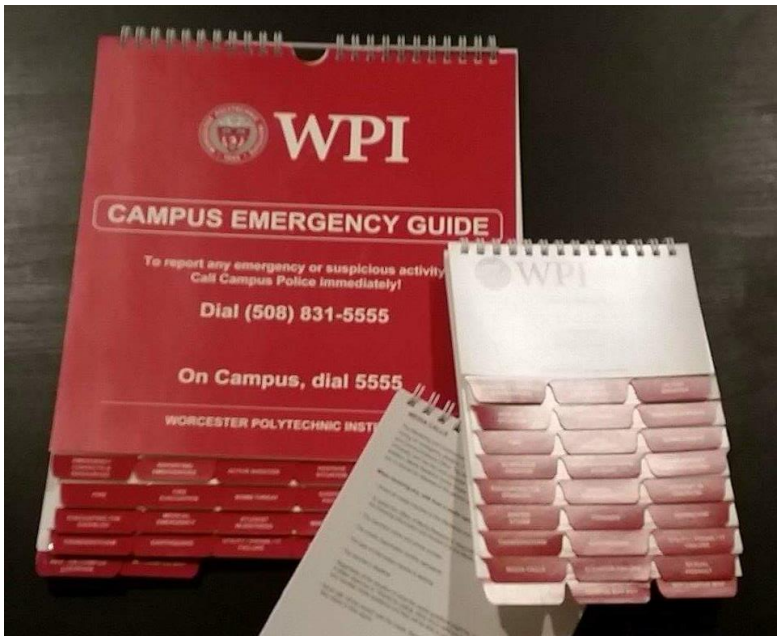

Figure 4. Copies of the WPI Campus Emergency Guide, provided to students in Act II.

In Act III, the "twist" occurred during the actors' in-class appearance as the three key stakeholders. Students received printed material expanding on the original reports with additional information such as the approximate time and location of attacks, and an article from a fictionalized version of the Boston Globe revealed that the attacks were gender-motivated. Students worked with actors and among themselves to revise their proposals to account for this new information.

In Act IV, students completed and presented their final revised proposals. A Post-Mortem Discussion was held in class, moderated by all three Authors, and students also performed additional reflective exercises and assessments. Students were awarded a token of completion – an ARG tradition – bearing the slogan "Human in the Loop."

This ARG structure greatly emphasized student research and supported such research with both intradiegetic and extradiegetic information in the form of handouts and online documents. Research here acted as the crucial discovery mechanic and was leveraged as both a main "gameplay" beat and a pedagogical exercise, putting elements that are often at cross purposes into alignment. Clearly defined research goals acted as the "win conditions" of the ARG to further align exploration and directed learning. This is emphasized in the ARG structure itself, where major narrative milestones such as the key stakeholder meetings and the "twist" were organized around research goals so the combined gameplay/learning elements fit naturally within the narrative.

Student Reflection and Self-Assessment

At the end of Act IV students were asked to complete a survey-style Student Assessment, a survey-style Self-Assessment, and an essay-style group Post-Mortem Analysis. Students also participated in a classroom Post-Mortem Discussion lead by all three game designers. As the work of Squires et. al. indicated, systems engineering practice requires intentional and deep self-reflection in order to help students process experiential learning and be able to generalize that learning into abstract knowledge. The Student Assessment required students to assess their peer group members while the Post-Mortem Analysis and Post-Mortem Discussion, long mainstays of game design practice, asked student groups to reflect together on successes, failures, and things they could have done better during the project. Collecting this information in both a classroom discussion and written essay accommodated students' varied communication styles and allowed additional time for students to assess their own experiences. These reflective analyses were a rich source of information for researchers as well as a necessary pedagogical exercise for students. This deep reflection also helped students internalize the importance of accounting for human factors such as gender dynamics within their systems engineering discipline. Finally, this helped students experience a realistic interface with system uncertainty and mitigation using systems engineering tools and processes.

Data Collection and Future Applications

The Authors will collect detailed data on student experience and learning outcomes to assess this pilot experience. The main points of data collection will concern students' self-reported and demonstrated awareness of humanistic concerns within the Systems Engineering discipline and their ability to address them appropriately during the Decomposition and Definition process: the Student Assessment, Self-Assessment, Post-Mortem Analysis, and, less formally, the Post-Mortem Discussion. Additionally, student and group performance on in-ARG assignments will be considered to understand whether the ARG implementation impacted academic performance.

Results of data collection will allow the Authors to produce a scenario-based module for use in an upper-level or graduate Systems Engineering class designed to teach humanistic concerns within the framework of an ARG. This module will include a generalized syllabus and classroom materials and activities, including guidelines for reflection and post-mortem activities. Data collection will also allow the Authors to produce documentation of best practices on designing and administering such a

module so that future implementations will be successful and require little overhead or knowledge of ARG design on the part of the instructors.

References

Cohen, I., Iluz, M., and Shtub, A. (2012). A Simulation-Based Approach in Support of Project Management Training for Systems Engineers. Systems Engineering 17 (1). doi:10.1002/sys.21248.

Federal Highway Administration. (2013). Diagram of the systems engineering 'V,' which details the various stages that occur within the system's life cycle [jpg]. Retrieved from http://ops.fhwa.dot.gov/publications/tptms/handbook/images/fig21.jpg.

Flushman, T, Gondree, M., & Peterson, Z. (2015). This is Not a Game: Early Observations on Using Alternate Reality Games for Teaching Security Concepts to First-Year Undergraduates. *CSET'15 Proceedings of the 8th USENIX Conference on Cyber Security Experimentation and Test*. Retrieved from https://www.usenix.org/system/files/conference/cset15/cset15-flushman_063015.pdf.

Fullerton, T. (2014). What games do well: Mastering concepts in play. In W. G. Tierney, Z. B. Corwin, T. Fullerton, & G. Ragusa (Eds.), Postsecondary play: The role of games and social media in higher education. Baltimore: Johns Hopkins University Press.

Jagoda, P. (2013). Gamification and other forms of play. *Boundary 2, 40 (2)*, 113–144.

Koponen, J., Pyörälä, E., and Isotalus, P. (2014) Communication Skills for Medical Students. Simulation & Gaming 45 (2) 235 – 254. doi:10.1177/1046878114538915.

Laurel, B. (1993). Computers as theatre. Reading, MA: Addison-Wesley Professional.

McGonigal, J. (2011). Reality is broken: Why games make us better and how they can change the world. New York: Penguin Books.

Shapiro M. J., Morey J. C., Small S. D., et. al. (2004). Simulation based teamwork training for emergency department staff: does it improve clinical team performance when added to an existing didactic teamwork curriculum? Quality Health Care 2004, 13 (6), 417 - 421. doi: 10.1136/qshc.2003.005447.

Squires, A., Wade, J., Bodner, D., Okutsu, M., Ingold, D., Dominick, P., Reilly, R., Watson, W., & Gelosh, D. (2011). Investigating an Innovative Approach for Developing Systems Engineering Curriculum: The Systems Engineering Experience Accelerator. *2011 ASEE Annual Conference & Exposition*. Retrieved from https://www.asee.org/public/conferences/1/papers/1295/view.

Biography

Klew Williams

Klew Williams is a master's candidate and Research Assistant at Worcester Polytechnic Institute. Her focus is on interactive art, wearable technology, and delivering educational content in novel ways. Before returning to school, Klew worked for five years as a Product Manager, Project Manager and Software Designer in Denver, CO, where she was an internationally competitive bare knuckle fighter and karate instructor. She enjoys painting, gaming, and getting outdoors.

Alexandrina Agloro

Alexandrina Agloro is an Assistant Professor of Interactive Media & Game Development and Humanities and Arts at Worcester Polytechnic Institute. She's currently a co-chair of the Critical Race and Ethnic Studies Committee for FemTechNet, a multi-university collaborative feminist technology organization. She is the Futurist for the Latino Pacific Archive and is working on developing a line of ovulation-tracking jewelry that is both affordable and flawlessly stylish. As a community-based researcher and participatory designer, her speculative work is anchored in lived experience.

Shamsnaz S. Virani

Shamsnaz S. Virani, Assistant Teaching Professor of Systems Engineering at Worcester Polytechnic Institute, earned her Ph.D.in Industrial and Systems Engineering from The University of Alabama at Huntsville. Dr. Virani' s research interests include Modeling Based Systems Engineering (MBSE), Engineering Education and Team Mental Models. She is founding member of Empowering Women as Leaders in Systems Engineering (EWLSE), International Council of Systems Engineers (INCOSE), American Society of Engineering Education (ASEE) and Institute of Industrial and Systems Engineers (IISE).