Interplay to Facilitate Decision-Making Under Uncertain Maritime Operations

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ABSTRACT

Serious games (SGs) provide the opportunity to capture trainees' attention and facilitate the learning, practice, and mastery of operational skills in both training and operational settings (Hirumi & Stapleton, 2007). However, serious games and other educational software applications must be designed to effectively blend the elements of game, play, and story within an instructional framework to facilitate learning and job performance (Hirumi et al., 2016). Furthermore, the method selected to develop serious games must also leverage and balance the expertise of instructional designers and game developers to optimize game-based learning (Hirumi & Stapleton, 2007).

This validation study describes the iterative development of the *Party Island* (*PI*) simulation, a serious game (SG) designed to facilitate complex decision-making tasks under uncertain maritime conditions (Fiore et al., 2018; Song et al., 2018). Using Jacob's Ladder to integrate key components of both game design and instructional design (Hirumi et al., 2007), the game applies the InterPLAY instructional theory to evoke emotions, spark imagination, and facilitate experiential learning (Hirumi et al., 2017). We provide an overview of how the integration of key game design and instructional design principles, and practices transformed a laboratory simulation for evaluating complex decision-making under uncertainty into a serious game for maritime operations management and discuss the differences between the original *Party Island* simulation vignettes and the current prototype. The shift from a simulation for basic research to a competitive serious game for training is highlighted. Based on formative evaluation methods, we assess our current iteration of *Party Island* and discuss initial results with respect to learner performance and satisfaction. We conclude with a summary of our design, development, and findings, and detail how these will influence the continued development of *Party Island*, a serious game for training complex decision-making under uncertainty.

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INTRODUCTION

Due to advances in technology, simulation-based training is increasingly relied on for the development of learning environments supporting complex operational environments. One such area is training decision-making under uncertainty for operations in complex environments (Song et al., 2018). This includes research on the type of visualizations being used to enhance comprehension of uncertainty, to general training on decision support systems that scaffold complex cognitive processes. We drew from a subset of this research that examined the types of uncertainty visualizations used in training (Song et al., 2019), the type of learning and testing content (Fiore et al., 2018) and feedback (Song et al., 2018) used in training, the use of cognitive efficiency as a measure of training effectiveness (Song et al., 2018), and ensuring that the sample populations with sufficient prior knowledge of uncertainty visualizations are recruited for training evaluations (Song et al., 2019). From this, we expanded into exploration of how such simulations can be used to develop serious games (SGs) that enhance training by increasing engagement with the learner.

Given the dramatic changes in learning environments in recent decades (Reiser, 2017; Johnson et al., 2012), researchers have proposed that games and the application of game elements and mechanics within instruction may be one effective method for increasing student engagement and improving instructional outcomes (e.g., Danka, 2020; Fabricatore, 2014; Ritterfeld et al., 2009). Irrespective of type, games make up an industry worth over 173 billion dollars (Grand View Research, 2019; Grand View Research, 2020), with at least three billion people worldwide gaming on a regular basis (DFC Intelligence, 2021). Given the success of the gaming industry, it is only natural that scholars would be intrigued with this form of interactive media, and in how to bring lessons learned from the entertainment domain into education and training applications. For decades, researchers have studied the relationship between learning and gaming (Abt, 1970/1987; Sawyer, 2002; Wilkinson, 2016), and there has been a growing consensus that using games or game elements and mechanics can improve instructional outcomes for learners (Federation of American Scientists, 2006; Sitzmann, 2011), evident in domains including education (de Freitas 2018), healthcare (Lu & Kharrazi,2018), and defense (Susi et al., 2007).

While the exact differences between games and traditional simulations used in training have been a subject of academic and professional debate, the Highly Interactive Virtual Environments (HIVE) taxonomy developed by Aldrich (2009) has succinctly classified three broad categories: (1) virtual worlds, identified as unstructured environments that capture/convey social cues; (2) games, described as a form of fun and engagement that build awareness of a topic; and (3) educational simulations, conveyed as highly structured environments modeling a real-life activity, often requiring an instructor (e.g., flight simulator). While several definitions for serious games exist (Breuer and Bente, 2010; Michael & Chen, 2006; Susi et al., 2007), SGs would fall within the category of games under this framework (Aldrich, 2009), in that they include engaging experiences designed for the primary purpose of supporting training.

SGs provide one means of capturing trainees' attention and engaging them to learn, practice, and master operational skills (Grossman et al., 2014; Hirumi & Stapleton, 2007). SGs must effectively blend instruction with entertainment to accomplish these goals (Arnab et al., 2015; Hirumi et al., 2016; Hirumi & Stapleton, 2007). However, SGs which have not been systematically designed or theoretically grounded may not effectively mix these elements and fail to result in positive instructional outcomes (Hirumi et al., 2016). For example, effectively overstimulated players may be unable to perform the cognitive processing necessary for learning (see Huang & Tettegah, 2014). Given that many existing theories of instruction and instructional design do not account for factors relevant to the design of SGs, we chose to ground *Party Island* (*PI*) within the InterPLAY instructional theory. InterPLAY (Stapleton & Hirumi, 2014; see also Hirumi et al., 2016) has been used to facilitate the instructional systems design process by integrating three components of interactive entertainment (i.e., story, play, and game), with three elements of instruction (i.e., objectives, assessment, and strategies), and three principles for experiential learning (i.e., framing, activating, and reflecting) within six instructional events (i.e., expose, inquire, discover, create, experiment, and share).

In this paper, we explored the development and extension of a simple experimentation simulation into a SG grounded within the InterPLAY instructional theory while following a systematic instructional systems design process (Dick et al., 2015a). Additionally, we evaluated, with the help of experts, the relevance and aptness of the instructional content and gaming elements.

INSTRUCTIONAL DESIGN OF PARTY ISLAND

The serious game (SG) *Party Island* originated and expanded upon a research program and experimental materials developed by Fiore and colleagues to examine decision making under uncertainty (Fiore et al., 2018; Song et al., 2018; 2019; see Figure 1). As discussed, the low-fidelity simulation using vignettes was used to test different aspects of decision-making under uncertainty (e.g., visualization, content, feedback, measures, population). While that simulation addressed the experimental needs identified by Fiore and colleagues (Fiore et al., 2018; Song et al., 2018; 2019), it was not developed to be a training tool. Rather, it was designed to study uncertainty in decision making by matching the cognitive fidelity of naval operations in the area of drug interdiction. Specifically, it required operators to consider how various resources used by a team can be used to identify and capture items located somewhere in unknown areas of the ocean. Because the subject population was undergraduates, to simplify this context, the scenarios were modified to *Party Island* so that it was more understandable and more relatable. However, the simulation was not designed as a training environment and, as such, it was not developed to engage learners within an instructional setting. Thus, the motivation for our work was to expand on the development of that simulation using the InterPLAY instructional theory to increase learner engagement and develop an effective serious game. *Party Island* became a serious game in which players manage various resources (e.g., vessels, intel, currency) to locate and secure the supplies (e.g., food, drinks, games) needed to throw an epic party on a remote Caribbean island while competing with rival captain(s) and dealing with several facets of complexity and uncertainty involved in maritime operations.

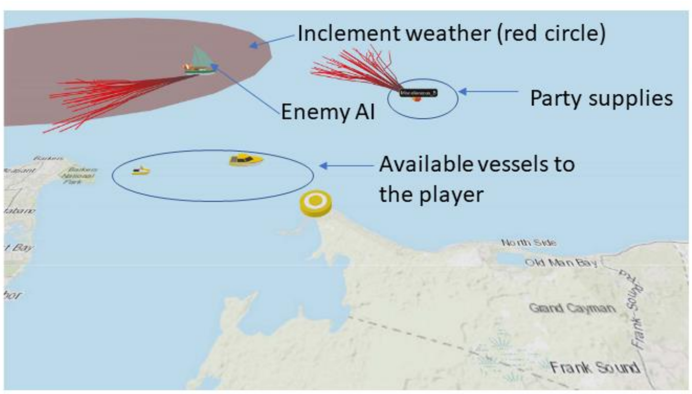

Figure 1. Image of the Original Party Island Simulation Vignette

We grounded our instructional design in the InterPLAY instructional theory, as discussed in the introduction (Hirumi et al., 2016; Stapleton & Hirumi, 2014). To assist with this process of blending elements of instruction and entertainment, we also used the Jacob's Ladder pre-production design framework (Hirumi & Stapleton, 2007; see also Brown-Turner, 2017) to ensure that we addressed both elements throughout the systematic instructional design process (Dick et al., 2015a). Essentially, Jacob's Ladder has been used as a framework for integrating instructional design considerations (i.e., learners, learning outcomes, content/subject-matter, instructional strategies, learner assessment, performance context) with entertainment design considerations (e.g., market, story, experience, play, game, venue) through a series of design discussions framed around specific questions (i.e., "who cares?", "why care?", "where do we go?", "what do we do?", "how does it work?", "in what context?"). Throughout our systematic design process, we used the Jacob's Ladder design framework to guide our efforts to balance these instructional considerations (e.g., training personnel in decision making under uncertainty) with considerations for addressing player engagement (e.g., story, game, and play elements) within the serious game. For example, we aligned the intended instructional goal from the whole-task goal analysis (described below; see figure 2) with the primary gameplay mechanic of tactical decision-making, based on rising action plot events of the story. This was in congruence with the progression of scenarios derived from that goal analysis, and it aligned with our instructional strategies based on the classification of that instructional goal as an example of problem-solving (see Jonassen, 2010/2011).

Beginning with analyses of the learners/market, we determined that training for complex-decision making under uncertainty was needed for military personnel involved in planning and conducting maritime operations (e.g., drug interdiction). We identified our target learners as Navy and Coast Guard junior personnel (e.g., military cadets), and following psychographic analysis, several learner personas were created to guide development and inform the design of the game's characters (story element). A whole-task goal analysis was then conducted, and the following terminal instructional objective was developed: "Under varying conditions of uncertainty, players will make tactical decisions to solve problems within increasingly complex scenarios" and aligned this with the objective of the *PI* serious game (game element). A series of simple-to-complex scenarios supporting the objective were developed and complexity factors (e.g., type and quantity of available vessels, objectives, adversaries, degree of uncertainty) involved in each scenario (Figure 2). These were used to inform the development of the game's plot events (story element).

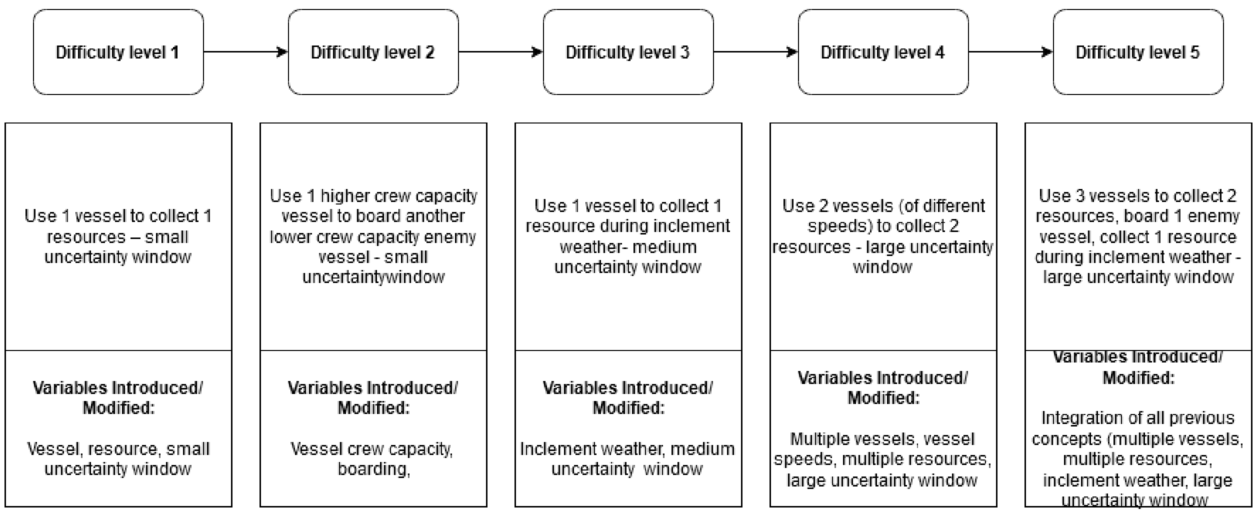

Figure 2. The Simple-to-Complex Scenarios of Increasing Difficulty Produced for Party Island

Concept Development

Following this, we focused the remainder of our efforts in the pre-production phase on elaborating upon the experiential (story, play, and game) elements of *PI* and aligning these with the instructional strategies and events presented within the InterPLAY instructional theory, while iteratively developing the prototype used for our formative evaluation. To support this effort, we created a series of concept documents, one for each of the three different types of elements (i.e., story, play, and game). The designers individually created drafts of each concept document, and then collaborated to create a second aggregated draft focused on each of these elements.

For the story concept document, the designers developed a theme to guide the narrative, detailing both the instructional context and pedagogical foundations of the serious game, and then described the major characters (e.g., character archetype, character arc, relevance to the story, demographic information, and appearance), the story settings (in terms of the starting point, destinations, safe havens, hostile territories, and neutral territories, as well as applicable rules and laws, climate, technology, demographics, and cultural information) and outlined the major plot events (hook, ordinary world, inciting incident, rising conflicts, climax, and resolution). For the play concept document, the designers selected and detailed a primary gameplay mechanic (i.e., tactical decision-making) as well as the alternate perceptual stimuli, actionable responses, and game consequences afforded to players as a result of that mechanic, in adherence to the InterPLAY instructional theory. A similar process was used to delineate the secondary play mechanics (e.g., resource collection; resource management). Finally, for the game concept document, the designers detailed the game goal and win/loss conditions, the game rules, and the tools available to players. Following this process, the designers collaborated to create a single unified document which outlined each of these elements and the products of their instructional design through the pre-production phase, briefly summarized below.

Story (Characters, Plot, Setting)

The story elements we developed for *Party Island* consisted of: (1) characters, based on our analyses of learners; (2) a series of plot events, based on our whole-task goal analysis; and (3) settings, based on our performance context analysis and other supporting story elements. Essentially, the story of *PI* revolves around the protagonist's efforts to retrieve supplies lost in the sea in order to help the islanders of a remote Caribbean Island throw a party. Using the prototypical characters outlined in Joseph Campbell's 'hero's journey' (Campbell, 1949/2008), we developed a mentor figure (retired Navy officer Davy Jones) and a sidekick (Anny) to help the protagonist along the way through a series of rising conflicts and to overcome the challenges presented by the antagonist (Chad).

Play (Stimulus, Response, Consequence)

The play elements we developed for *Party Island* consisted of a primary mechanic and a series of secondary mechanics, defined in terms of the possible stimuli, responses, and consequences associated with each mechanic. Based on previous literature on game mechanics (Hirumi and Hall, 2010), we identified our primary mechanic as tactical decision-making, the stimuli consisting of the circumstances of the board and player resources during each turn, the responses consisting of the different actions available to players during different phases of each turn, and the consequences consisting of the rewards/punishment's players receive for making choices varying in suitability given the dynamics of the game. Secondary mechanics related to the types of actions which players could perform during different phases of the game, including (1) collecting, allocating, and managing resources, (2) earning victory points, (3) responding to random events such as inclement weather and piracy, and (4) collecting rewards (e.g., vessel skins, achievements) unrelated to players' progression toward the objective of the game.

Game (Rules, Tools, Goals)

The game elements we developed for *Party Island* consisted of: (1) rules, developed to support the primary and secondary mechanics discussed in the previous section; (2) tools, corresponding with and expanding upon the players' resources; and (3) goals, aligned with the terminal instructional objective identified as the result of our whole-task goal analysis. Two examples of tools developed for the game included "Intel Cards", which provided players with information on hexes where lost supplies may be found given uncertainty, and "Morale Cards" which could be used to provide players with additional resources, power-ups, or random events.

As a turn-based strategy game, the game elements were designed to support players' collection, allocation, and management of resources (e.g., vessels, supplies, tools). The game was designed for 1-4 player (with single player and multiplayer gameplay options) and featured a 2D hex-based grid for navigation depicting part of the Caribbean Sea, islands, oceans, hazards (e.g., inclement weather, adversaries), and miniature vessels (Figure 3).

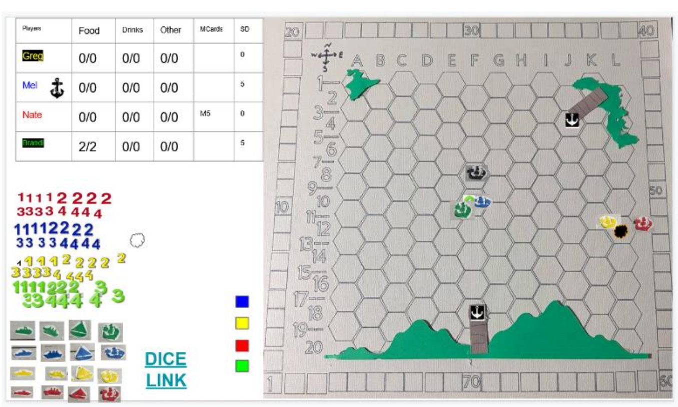

Figure 3. An Image of the Third Pre-Alpha Prototype for Party Island

Throughout the design process, we iterated upon prototypes of *PI* and conducted a series of evaluations to collect actionable data to inform each step of the design process through the pre-production phase. In the next sections, we will discuss the methods used to evaluate these early pre-production prototypes of the SG and our findings.

METHODS

After comparing various evaluation methods (e.g., Dick et al., 2015b; Gee et al., 2014; Sauvé et al., 2008; Tessmer, 1993/2005), we elected to use formative evaluation methods including small group evaluation, expert reviews, and one-to-one evaluations of the *Party Island* SG, given that the versions of the game evaluated were from the pre-alpha stage of development (see Hirumi & Stapleton, 2009; Bruch et al., 2017).

Evaluation Criteria

The criteria used to guide this formative evaluation were developed based on the intersections of the *InterPLAY* instructional theory (Stapleton & Hirumi, 2014; see also Hirumi et al., 2016) with the Attention Relevance Confidence Satisfaction (ARCS) model of motivation (Keller, 1987). Essentially, the informal discussions with the experts following each stage of formative evaluation were guided by the designers' interest in the extent to which the elements of story (characters, plot, settings), game (goals, rules, tools), and play (stimulus, response, consequence) developed within *Party Island* could motivate target learners along dimensions of attention, relevance, confidence, and satisfaction (Keller, 1987; Stapleton & Hirumi, 2014). Example questions of the intersection between InterPLAY and ARCS models asked to the reviewers were depicted in Table 1. We referred to this as the InterPLAY x ARCS framework.

Table 1: Example Questions of the InterPLAY x ARCS Framework

Game Element (InterPLAY theory)	**Reaction** (ARCS model of motivation)
Story	I feel confident in my understanding of the game's setting (Confidence)
Game	I think the game's rules are interesting / engaging (Attention)
Play	I think the game's challenges are relevant to making tactical decisions during maritime operations (Relevance)

The goal of this formative evaluation was to capture reactions and feedback from experienced subject matter experts (SMEs). We focused on ways to improve game elements using informal methods of formative evaluation guided by intersections InterPLAY x ARCS framework, in such a way that the elements of instruction and engagement could be improved for the next stage of game development. Ten SMEs were consulted to carry out these formative evaluations of the *Party Island* serious game, chosen for their expertise relevant to instructional design, military training, and/or gaming, as described below.

Small Group Evaluation

Four graduate students enrolled in a large university in the Southeastern United States with instructional design backgrounds participated in a small group playtest of the first pre-alpha prototype of *Party Island*, focusing on players' satisfaction with the game elements (goals, rules, and tools). *Party Island* was revised based on input received from these students. Pertinent recommendations were included in the subsection on Future Development.

Expert Review

After the small group evaluation and revisions, four U.S. military academy cadets served as SMEs to review the second pre-alpha prototype of *Party Island*. Although cadets are not traditional SME's, they are representative of the end user community for this type of SG; that is once they've graduated their future responsibilities would include engaging in tasks requiring decision making under uncertainty. These experts had a combined 16 years of experience relevant to military training and included members with operations or human factors expertise. All SMEs examined the prototype for the full set of evaluation criteria and were asked for feedback on the design of *PI* during the informal discussions which followed their review. Pertinent recommendations were included in the subsection on Future Development.

One-to-One Evaluations

Following the expert review session, two avid game enthusiasts with over 40 years of card, board, and roleplaying game experience, reviewed the third pre-alpha prototype of *PI*. Based on the feedback obtained from the previous formative evaluations, these experts examined the rulebook developed for *PI* for both game mechanics (rules, tools, goals) and play (stimulus, response, consequence), and were asked for feedback on the clarity of the rules, the perceived 'fun', and the interaction of the game mechanics (e.g., probability of actions, perceived cost/benefit of actions, and tools) of *PI*. Pertinent recommendations were included in the subsection on Future Development.

RESULTS

Results: Small Group Evaluation

The small group evaluation revealed that multiple aspects of the game's mechanics required revision. Overall, players noted the pace of gameplay was slow (due to few actions per turn). Additionally, gaining momentum in the game was difficult partly due to a lack of available resources (e.g., intel cards). Players also noted the probabilities of the dice rolls seemed too difficult (e.g., occurring too infrequently) and felt they were 'wasting' their turns.

Actions taken within one's turn appeared to be understood and utilized correctly. Players easily moved across the board, collected supplies, and gained points and currency. However, players struggled to take an active role in collecting supplies at the beginning of gameplay due to how many intel cards had been drawn. The player-versus-player (PVP) secondary mechanic was not utilized as players felt the risk of losing was not worth the reward of gaining their fellow player's supplies. Morale cards were also underutilized as players often forgot to purchase and/or apply them. Pacing between player's turns was smooth. However, only providing players with one action per turn caused a lag in the actual collecting of supplies. While the board provided accuracy in terms of supply location, the lack of a specified "start space," resulted in confusion at the beginning of gameplay. The end game, in which players lost five points for every supply not retrieved, was intended to reduce the likelihood of players focusing more on gaining points than completing the scenario. This mechanic was perceived by players as too harsh a punishment.

Results: Expert Review

From our informal discussions with the SMEs based on the InterPLAY x ARCS framework for our formative evaluation of the second pre-alpha prototype of *Party Island*, we determined that the greatest weaknesses of the serious game were related to the capability of the game and play elements (i.e., InterPLAY) to motivate target learners along the dimensions of relevance and satisfaction (i.e., ARCS). Specifically, we determined that target learners found both game elements (rules and tools) and play elements (stimulus, response, and consequence) to lack relevance for training tactical decision-making in maritime operations.

In particular, the experts expressed concerns that these elements of *Party Island* did not reflect the stress and complexity of operations in the performance context, and that additional complexity would be needed to motivate target learners. This sentiment impacted several dimensions of the InterPLAY x ARCS analysis framework. For example, the SMEs described how there are numerous considerations and restrictions in military operations for where and how maritime vessels may operate in largely civilian domains, this important mechanic supporting the relevance of the training was not reflected within the game rules. The experts stated that the game was simply too easy. The experts made several suggestions for increasing the complexity of the game: by adding elements of time pressure (e.g., allowing only 10 seconds to perform an action), increasing the player's level of task saturation (i.e., the number of tasks to complete simultaneously), and increasing the consequences of player decisions and the likelihood of failure. They specifically mentioned that they have had tests as military personnel involving the management of six or more high-consequence and complex tasks simultaneously under time pressure (i.e., task saturation), and that the game elements should be improved to reflect that type of stress and complexity. The experts also indicated that there were not enough possible methods for either completing the game objectives or failing to achieve those objectives.

We determined that *PI*'s greatest strength as a SG was the capability of its story elements (characters, settings, and plot events) to motivate learners along each dimension of ARCS (i.e., attention, relevance, confidence, satisfaction). One expert indicated disappointment in that the game goals were not better aligned with one of the character's story arcs (i.e., saving Davy's charter boat business). The experts also expressed a high level of confidence in understanding the game elements, as reflected in their feedback regarding the lack of difficulty in *PI*. However, the experts generally gave mixed or neutral feedback regarding their interest/engagement and satisfaction with game and play elements.

Results: One-to-One Evaluations

From the one-to-one evaluations, we determined that the greatest weaknesses of the third pre-alpha prototype *of Party Island* were related to game, specifically rules. Both SMEs mentioned that the clarity of instructions was not structured in such a way as to be easily understood by the player, such that the reviewers needed to frequently search for the relevant rules and information. One recommendation from the reviewers to improve the instructions was to create a quick reference sheet (e.g., job aid) that contains the relevant information to facilitate play for players to reference, and not have to explicitly review the rulebook. Additionally, relating to the rulebook, one reviewer made note that instructions were not only difficult to follow, but were not engaging (i.e., 'boring').

For goals, the reviewers shared a similar view as the military SMEs, that there were too few paths to victory and/or failure. Additionally, the reviewers identified the need for an 'ultimatum' or end game mechanic, where the player must complete objectives within a tightly limited amount of time (either via turns or timer), as the current prototype allowed the players to continually collect items with no forced end game. For relevance to the goals, it was unclear to the reviewers how the progression of the game levels related to the actual game, and that the difficulty between levels seemed to be an uneven progression level.

For tools (i.e., intel, morale), the reviewers thought they were interesting, however, they also found them to be too limited in scope. One suggestion from the reviewers was to add a hidden mechanic to the intel cards, which would provide possible alternative game play styles. While we did not explicitly ask the one-to-one reviewers to explore the story elements, they did have access to the material (e.g., characters, plot, theme). Reviewers noted that while the characters were interesting, they did not add to the gameplay; for example, the characters did not provide any asymmetrical abilities (i.e., tools) for players to exploit.

For play, reviewers made note it was too basic, with the actions available to the player too limiting to be challenging or rewarding. Additionally, they noted in the current prototype, two of the four available vessels (i.e., boats) were effectively useless, as the other vessels outperformed by a considerable margin and recommended a rebalancing of all vessels. Lastly, they expressed concern that the random number generations of the various aspects of the game would make 'optimal decision making' difficult if not impossible, and noted it seemed mostly like 'output randomness'.

DISCUSSION

Comparison Between Laboratory Vignettes and Serious Game

In this paper, we extended a laboratory simulator (i.e., vignette) and through the application of the InterPLAY instructional theory (Stapleton & Hirumi, 2014; see also Hirumi et al., 2016), we turned it into a serious game. While the original simulation vignette provided robust methods for evaluating knowledge acquisition and transfer, it failed to provide a framework to engage learners or to address decision-making skill in a real-world context. By expanding on the original simulation concept using the InterPLAY framework (story, game, and play) we applied elements shown to increase learner engagement (Hirumi et al., 2016). While adding a narrative and gamification to the original simulation takes us a step closer, it still does not fully address complex decision-making in a performance environment.

Similarities and Differences between Groups

Based on the interviews of three divergent groups (i.e., graduate students, U.S. military academy cadets, and game enthusiasts) a number of themes emerge across the interviews. All three groups focused primarily on game (rules, tools, goals) and play (stimulus, response, consequence), with only the cadets explicitly articulating interest in the story (characters, plot, setting). All three groups were in agreement that the game was easy, or too easy according to both the cadets and the gamers. Additionally, play was not complex enough nor fast enough paced. Specifically, both the cadets and gamers felt there was not enough time sensitivity or pressure to complete the objectives. For the cadets, this was an issue as the game needed to better represent military operations, while for the gamers, it was representative of lack of fun; in both cases it related directly to engagement. Both the cadets and gamers were in agreement that there were not enough win/loss options or paths to victory, with the graduate students silent on the matter. Both the graduate students and the gamers felt the random order generator (e.g., probability on the dice rolls) was not balanced, with the cadets implicitly agreeing with the statement, mentioning that it was not 'real' enough. As mentioned earlier regarding the story, only the cadets expressed interest in it, such that they liked the story, but wished it mapped onto the gameplay better; the gamers similarly remarked that they wished the story elements influenced the gameplay in some fashion. The graduate students made no reference to the story.

Limitations and Future Development

Several limitations for the development of the serious game and the formative evaluation were identified. With respect to development, serious game prototypes for *Party Island* were initially developed as a course project, and thus both time constraints and conflicting objectives were imposed during the design process. In terms of the formative evaluation, there were limitations in methods of evaluation used, in how the project materials were presented to SMEs, and the number of SMEs included in the evaluation. First, while several content experts were interviewed across three different evaluation methods (i.e., small group evaluation, expert review, and one-to-one evaluations), a larger field test was not conducted to gain additional perspectives and to quantify the effectiveness of the serious game. It was also difficult to condense the entire scope of instructional design work into presentable formats for the SMEs, and game materials and experiences often needed to be omitted from these formative evaluations. Finally, while the formative evaluation consisted of three different perspectives (e.g., instructional design experts, military personnel, and gamers), additional experts representing different types of expertise could have been included in these formative evaluations, given additional time and other resources.

Additionally, while the game was designed to train complex decision making under uncertainty, the 'surface' of the game was encapsulated in a fantasy world of parties and rivalries. While not explicitly stated by any reviewer, it could be that the lack of story engagement reflects the fantasy nature of the story. One possible solution would be to 'reskin' the surface level of the story into a more realistic narrative about naval drug interdictions, which may elicit a more engaged response. Additionally, deeper game and play mechanics should be incorporated from the feedback provided from all three interview groups to add increased complexity. After incorporating feedback, one possible future direction would be to administer a larger survey and to run inferential statistics on the collected data (e.g., field test). Additionally, a broader range of content experts would ensure a more well-rounded and interdisciplinary approach to the development of the serious game.

Lessons Learned

Based on our experiences designing and evaluating the SG *Party Island*, based on the InterPLAY instructional theory, we learned a few lessons that may be valuable to other instructional designers and practitioners developing SGs. Foremost, this experience reiterated the importance of prototyping and iterative development. It was fortunate that we used a systematic design process and did not begin development on a functional digital prototype of the game (e.g., a beta version). This was because there were elements we determined, following the formative evaluation, which needed to be redesigned beforehand, and because other resources should be invested into the development of production elements. While the SMEs generally expressed that the story elements were engaging, the feedback provided indicated that a rework of the game elements (rules and tools) and play elements (stimuli, responses, consequences) needs to be addressed. Given the results of our formative evaluation, the development of higher fidelity production elements would not be advisable before iterating upon the design of *Party Island* and conducting further formative testing to ensure that these elements become more relevant to making tactical decisions during maritime operations.

On a related note, we learned that the development of SGs should incorporate a *participatory design* approach whether it has been guided by Jacob's Ladder pre-production design framework (Hirumi & Stapleton, 2007; see also Brown-Turner, 2017) or another systematic process. Participatory design is an approach to design that includes stakeholders within the design process (Elizarova et al., 2017; Lukosch et al., 2012; Wanick and Bitelo, 2020). For *Party Island*, this would have involved recruiting a member of the target population to be included not just within an SME role, but on the design team itself. Given our experiences and the relevant literature (e.g., Lukosch et al., 2012; Wanick and Butelo, 2020), adherence to participatory design may have preemptively resolved many of the affective issues we discovered during the formative evaluation, and may have saved time during the development process.

Furthermore, additional time and efforts may have been saved through the design process had a list of requirements been created and adhered to throughout the instructional design process. Unlike traditional systems engineering processes (e.g., Fairley et al., 2021), instructional design and game design frameworks often may not supplement their front-end analysis phases with *requirements specification* activities. Requirement's specification has often functioned to formally document and define stakeholder needs and expectations, to structure communications between stakeholders and designers with diverse roles and expertise, and to mitigate the risk of wasted effort and resources throughout the system development process (Bahil and Henderson, 2005; Bijan et al., 2013). Explicitly defining stakeholder and system requirements during the front-end analysis phase of instructional design as expressed in the systems engineering literature could present one method for ensuring that instruction has been guided by more than designer-centric concepts such as high-concept or theme (Stapleton & Hirumi, 2014; see also Hirumi et al., 2016) and grounded not just in theory but also within the performance context.

Related to this discussion of systematic design, another lesson learned was the importance of aligning gameplay elements and mechanics with instructional strategies and outcomes. Throughout literature and practice, there have been two opposing camps regarding the role of gameplay mechanics within the design of SGs; one has asserted that gameplay mechanics are only needed to motivate learners, while the other has contended that the gameplay mechanics should be congruent with the desired learning outcome (see Hirumi and Hall, 2010). The InterPLAY instructional theory has not promoted one camp over the other, and, as such, the design of *Party Island* defaulted to the former camp and did not attempt to align the selected gameplay mechanics with the instructional strategies or outcomes. The results of the formative evaluation of *Party Island*, demonstrating that there was a detriment to the motivation of the target learners caused at least in part by a lack of congruence between gameplay elements with instructional elements, may provide qualitative and anecdotal support for the need to align gameplay mechanics and other elements with instructional strategies and outcomes. However, existing taxonomies of game mechanics have failed to provide sufficient guidance for instructional designers to ensure this alignment (Sonnenfeld et al., 2021). While the development of *Party Island* and the results of its formative evaluation suggested that there may be an opportunity for instructional designers of SGs to improve learners' motivation through the alignment of gameplay mechanics with instructional strategies and outcomes, the need for actionable guidance in the literature as to how to structure that alignment (e.g., learner assessment alignment tables; Cook, 2018; Hirumi & Stapleton, 2009) also remained unfulfilled.

A final lesson learned was that the elements of story, game, and play as presented within InterPLAY instructional theory may alone not sufficiently encompass the essential element, the *sine qua non*, of player engagement. While the authors grounded the instructional design of *Party Island* within the InterPLAY instructional theory and adhered to associated systematic design processes, the early prototypes were not sufficiently relevant or satisfying to SMEs providing feedback on behalf of the target learner population. The feedback provided throughout the formative evaluation indicated that the lack of difficulty was an element which would hinder players' motivation to play and learn from *Party Island*. There may be an opportunity for future work on the InterPLAY instructional theory to include more structured considerations for how instructional designers should address the difficulty of game experiences and content. While a whole-task goal analysis was conducted, the extensive degree of scaffolding implemented in the series of scenarios developed may have hindered learners from extending their metaphorical zones of proximal development (McLeod, 2019). It may be useful to consider measuring the cognitive efficiency (Song et al., 2018; see also Cobb, 1997) of a single participant conducting a series of successively more difficult tactical decision-making scenarios in *Party Island* beyond those originally conceived for the goal analysis, in order to derive a better estimate of optimal scenario difficulty. Then, the difficulty of each successive instructional scenario may be adjusted to ensure that learners experience sufficient difficulty as to experience a flow state during gameplay (Shute et al., 2009; see also Cohen, 2011; Yerkes & Dodson, 1908). However, careful consideration should be given to players' cognitive load, to ensure that they are neither under- or over-stimulated (see Huang & Tettegah, 2014),

CONCLUSION

This paper provided a formative evaluation of a serious game designed to improve decision making under uncertainty in a maritime setting. The authors extended a simulation designed for an empirical study of uncertainty and turned it into a serious game by adding features to enhance learner engagement through story, game, and play. The authors further examined the intersection between two frameworks, one focused on enhancing learner engagement through adding elements of game (InterPLAY; Stapleton & Hirumi, 2014; see also Hirumi et al., 2016), while the other focused on measuring learner engagement and motivation (ARCS model of motivation; Keller, 1987). Using a series of formative evaluation methods, including small group evaluation, expert review, and one-to-one evaluations, we found that the serious game *Party Island* needed extensive redesign with respect to the capability of the game elements (rules and tools) and play elements (stimuli, responses, consequences) to be relevant and satisfying for target learners. This formative evaluation highlighted the need for expertise in multiple domains when developing a serious game, as each domain provides unique insights that will help improve the experience for the target learners. However, use of questions derived from a cross-section of the InterPLAY and ARCS frameworks allowed us to derive actionable insights from SMEs to guide future iterative development of the serious game *Party Island*.

While previous research has focused on other facets of training for decision making under uncertainty for operations in complex environments, this paper documented and evaluated efforts to systematically design a serious game to engage learners in support of that instructional goal, with what are hoped to be valuable lessons learned for instructional designers and the training community.

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