Developing and applying an accelerated learning framework for game-based training

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ABSTRACT

There is often limited time and resources for personnel training due to environmental and situational constraints, emphasizing the need for appropriate training strategy selection. This challenge increases when training cognitive skills, such as rapid decision-making in complex environments. Accelerated learning offers approaches to improving skill mastery efficiency while maintaining, or potentially enhancing, instructional quality. The concept of accelerated learning focuses on developing an active, engaging, and collaborative environment that emphasizes the learner's role in achieving expected outcomes. While accelerated learning models exist, there is limited research on the connection between the underlying learning theories that drive the models, principles, and training outcomes. Further, there is little guidance on instructional strategy selection based on accelerated learning principles. Presented here is a hybrid accelerated learning framework developed to inform the design of a game-based training solution. The game aims to accelerate the acquisition of rapid, practical decision-making skills in complex environments. The framework was developed and applied in the context of military operations on urbanized terrain (MOUT). Military urban operations are characterized by a need for rapid decision-making under high-risk conditions due to evolving environmental, adversarial, civilian, and mission factors. The framework has practical utilization beyond MOUT operations, but this use case provides an exemplar context for the framework application.

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INTRODUCTION

There is an ever-pressing and increasing demand for a highly skilled workforce, especially in national defense, where combat-ready warfighters are often needed at a moment's notice. Many factors drive this demand, such as senior-level personnel reaching retirement age, increased entry-level recruitment, competition with adversaries, technological changes to job tasks, and general growth of domain knowledge and information. Meeting workforce demands call for innovative approaches to train new and advancing personnel. The concept of accelerated learning has been identified as a means to achieve the workforce and warfighter goals set by the defense services. For instance, one of the U.S. Navy's Sailor 2025 initiatives aims to "…accelerate learning for faster response to rapidly changing warfighting requirements in increasingly dynamic operational environments (U.S. Navy, 2019)." The notion of accelerating learning lies in the desire to achieve higher-level skill sets within less time without compromising the quality of instructional design or skill retention (Andrews & Fitzgerald, 2010).

There are clear motives for accelerating learning across all services (Andrews & Fitzgerald, 2010):

- Complexity of conflicts characterized by irregular warfare intended to disrupt traditional wartime patterns
- Warfighters are expected to perform ill-defined tasks under extensive time pressure and need to develop situational understanding to dynamically plan and respond to adversarial actions
- There is a need to eliminate barriers to retaining knowledge and skills from the onset of learning to its real-world implementation
- Real-world experiences are often limited or unavailable, reducing reinforcement opportunities to enhance knowledge and skill sets

To meet these challenges, training must instill expert-level skill sets across ranks to achieve combat readiness and squad overmatch. Modern training technologies, such as serious games, have the potential to accelerate learning through repeated exposure to various, dynamic, challenging scenarios, encourage peer collaboration, and expert-level guidance and feedback. Game-based training holds promise for accelerating the acquisition of cognitive skills critical to addressing the challenges, but sound instructional design grounded in learning theory and research must be applied.

The Military and Serious Games

Serious games have been implemented for military training in many countries and have effectively provided experienced-based learning for cognitive, affective, and procedural training (Goldberg, Knerr, Grosse, 2005; Roman & Brown, 2008; van der Hulst, 2013). Serious games, for purposes here, refer to games intended to teach or train and are outside of pure entertainment (Arnab et al., 2015). Digital games are interactive programs played on an electronic platform or system (Brkljačić, Sučić, Tkalić, Wertag, & Lučić, 2019). The U.S. military has embraced digital game-based training solutions since there is an understanding that most recruits today are digital natives and therefore, would be more receptive to modern approaches for educating and training (Prensky, 2007).

Digital natives tend to be multimedia-oriented, socially networked, consistently connected through their digital devices, and often play video games. Although there may be negative consequences to constantly interacting with electronic devices, performance benefits are also realized. In a comprehensive review of vigilance enhancement (Al-Shargie, Tariq, Mir, Alawar, Babiloni, & Al-Nashash, 2019), the research found that playing action video games led to improvements in perceptual (Li, Polat, Makous, & Bavelier, 2009), visuospatial (Feng, Spence, & Pratt, 2007; Ferguson, 2010), perceptuomotor (Fischer, Kubitzki, Guter, & Frey, 2007; Li, Chen, & Chen, 2016), and attentional

abilities (Green & Bavelier, 2003). Further, playing action video games has benefited users regarding cognitive functions, such as cognitive flexibility (Green, Sugarman, Medford, Klobusicky, & Bavelier, 2012) and updating working memory (Colzato, van den Wildenberg, Zmigrod, & Hommel, 2013). Separately, neurological studies found video gameplay led to increases in the gray matter within areas of the frontal lobe associated with abstract reasoning, problem-solving, and decision-making (Colom et al., 2012; Kuhn, Gleich, Lorenz, Lindenberger, & Gallinat, 2014). These findings, along with the breadth of evidence within the literature, further suggest digital game-based training solutions should be implemented across the military services.

One of the U.S. military's first successful serious digital games was America's Army, released in 2002, intended to enhance recruitment (Allen, 2017). Beyond the game's explicit intention, it was reported that a civilian with no prior medical training leveraged what was learned from a medical lesson in America's Army to provide medical aid to car crash victims (Mezoff, 2008). The game's content was realistic enough to showcase an inside perspective of Army careers, such as combat medic. Even without the intent of training, skills were not only acquired but also effectively transferred to a real-world scenario. That is training's holy grail. Lessons can be taken from this situation that have later been supported through research: 1) video games can be leveraged for training, 2) content should be optimally realistic, 3) practicing skills within a video game environment can transfer to the real world, and 4) skills learned in a video game can be retained over long periods. The military has seen the evidence in support of digital game-based training and has continued to explore and employ these solutions to train Servicemembers.

The question remains as to whether military personnel's cognitive skill acquisition can be *accelerated* using serious games. One approach to answering this question is developing and evaluating an accelerated learning framework for game-based training design. While there are models and established principles of accelerated learning (Meier, 2000; Smith, 2003) and frameworks to evaluate accelerated learning within games (Lim et al., 2013; Petersen, Oliveira, Hestetum, & Sørensen, 2019), a framework for designing serious games for accelerating training does not exist.

ACCELERATED LEARNING FRAMEWORK FOR GAME-BASED TRAINING DESIGN

The main goal for this new framework is to provide awareness and a general structural process to guide the design of serious digital games to accelerate learning and training. The framework application proposes that training with serious digital games will effectively and rapidly transfer skills to real-world applications without compromising retention. Further, this framework complements existing models and frameworks for designing and evaluating serious games to provide a robust approach. To guide the development of the new framework, first, a literature review captured existing accelerated learning models and frameworks and empirically supported learning theories and instructional strategies to inform the essential components of the framework.

Literature Review Methodology

A review of the training and learning research literature was conducted to inform the accelerated learning framework for game-based training. In order to carry out the review, search engines known to compile articles across scholarly databases efficiently were utilized (e.g., Google Scholar). To direct the search further, specific technical databases (e.g., Defense Technical Information Center, I/ITSEC and MODSIM conference proceedings repositories) were accessed to find domain-relevant accelerated learning research. First, keyword searches focused on accelerated learning terms (e.g., accelerated learning, training, model, principles, or guidelines) to identify existing models. The initial search for accelerated learning models found few articles that discussed a model or one developed with a clear theoretical foundation. Once exhausted and seminal accelerated learning articles were identified (i.e., Meier 2000; Smith 1998), the research attempted to identify the underlying learning theories. Since such few articles discussed the theoretical foundation of accelerated learning, the researchers were required to deduce potential theories based on the accelerated principles and guidelines discovered. Therefore, as theories were identified and alignment with the accelerated learning models was drafted, validation by SMEs was determined to be a critical step (see Hybrid Card Sorting Task below). Once the set of learning theories was identified, the literature search expanded to incorporate other associated key terms applicable across domains (e.g., complex decision-making) and specific to the domain of interest (e.g., Marine squad decision-making training). The results of all these previous steps then directed the research into effective instructional strategies emphasizing, but not limited to, game-based approaches. The criteria to determine the retained instructional strategies were: 1) had to be guided by a learning theory and 2) had to have empirical evidence to support their effectiveness. The criteria did not limit the search within a specific domain, as it was expected that the results would be derived from various domains and applications. The result of the literature

review was an electronic spreadsheet document aligning all these described elements to guide and inform the creation of the new framework, core learning concepts, and game features.

Existing Frameworks

The Accelerated Learning Framework (ALF) proposed by Petersen, Oliveira, Hestetum, & Sørensen (2019) focuses on evaluating game-based learning environments within industry. The ALF is intended to be pragmatic by connecting theoretical constructs and models to domain applications. The ALF is based on Meier's (2000) seven principles of accelerated learning framework and accounts for other learning theories and game design frameworks (i.e., Zone of Proximal Development (Vygotsky's, 1978), Flow theory (Csikszentmihalyi, 1990), Activity Theory-based Model of Serious Games (Carvalho et al., 2015), immersive learning framework (de Freitas et al., 2010), comprehensive conceptual framework (Mayer et al., 2014), & learning mechanics-game mechanics framework (Arnab et al., 2014)).

Three core concepts are outlined for supporting accelerated learning (Petersen et al., 2019):

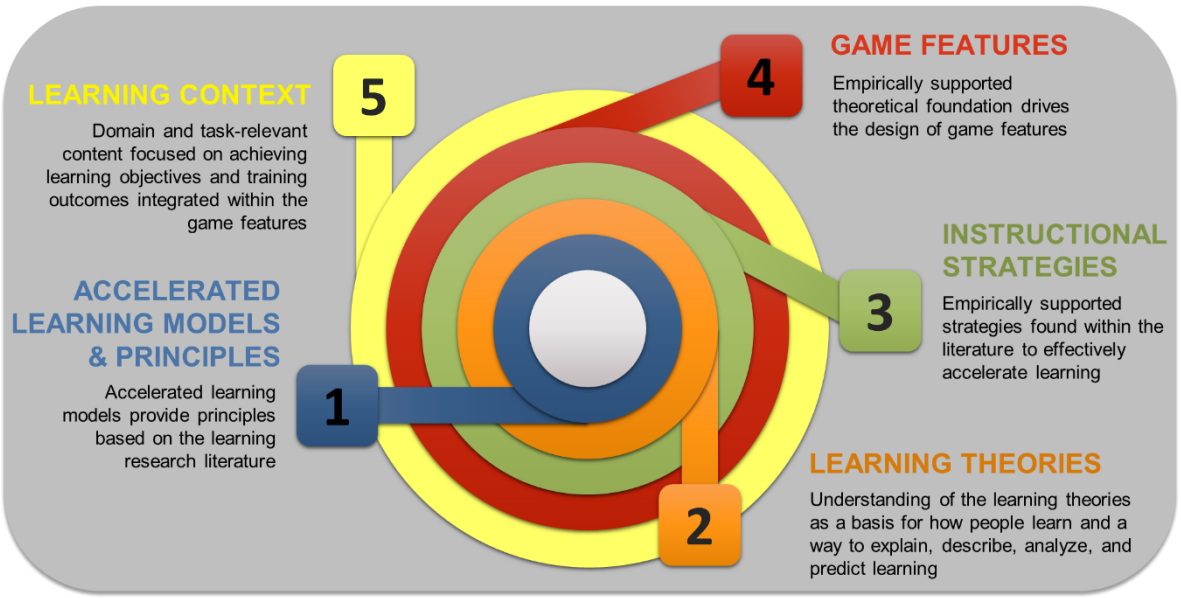
- Cognitive – Learner's higher-order thinking and deep understanding of concepts
- Affective – Learner's emotions, interests, attitudes, engagement, and motivation
- Context – The learning environment's reflection of relevant and realistic content and practice opportunities

Collectively, these three concepts work together to generate plans for learning progression, design appropriate learning content, support transfer to the work environment, and guide recommended evaluations to assess accelerated learning. While the framework provides general guidance to facilitate accelerated learning, the interactive opportunities that games provide require further guidance to exploit their full beneficial potential. Therefore, a game-based accelerated learning framework is proposed to build on the approach described and the foundation of these previous frameworks.

An Updated Framework

The accelerated learning framework for game-based training design was conceived based on accelerated learning principles, instructional design theory and research, and decision-making training research and practices. The framework is depicted in a concentric matrix that aligns the principles with theoretical foundations and practices (Figure 1). The five core layers are: 1) Accelerated learning models and principles, 2) Learning theories, 3) Instructional strategies, 4) Game features, and 5) Learning context. Each layer does not exist in isolation, but rather there is interplay across all layers with the theoretical assumption that accelerated learning will be the emergent property of this synergy.

Figure 1. Accelerated learning framework for game-based training (Image template by PresenationGo).



At the core of the framework are the accelerated learning models and principles, without which compromises the likelihood of its overall effectiveness. At this time, Meier's (2000) seven principles, along with Smith's accelerated learning cycle (1998), are two prominent recommended sources (Table 1). Future research may expand this list.

Table 1. Accelerated learning models & Principles.

Seven Principles of Accelerated Learning (Meier, 2000)	**Accelerated Learning Cycle (Smith, 1998)**
1. Learning involves the whole mind and body, with all the senses, receptors and emotions that go with it; 2. Learning is creation, not consumption and knowledge is not absorbed, but created. This assumes learning as the creation of new meaning and understanding and assimilating it into the work we do. 3. Collaboration aids learning; learning is better within a social context, and we often learn in collaboration with peers rather than in isolation. 4. Learning takes place on many levels simultaneously; learning is not a matter of one thing at a time but many things at once. 5. Learning comes from doing the work itself (with feedback), and real concrete situations are often better than hypothetical and abstract concepts. 6. Positive emotions greatly improve learning; learning that is joyful, relaxed and engaging is more effective. 7. The image brain absorbs information instantly and automatically; images are easier to retain than verbal abstractions.	*Connection (Introduction)* • This stage is about orienting the learner to the learning. *Activation (Confident and Critical Execution)* • This is where learners find the information and begin to make sense of it. *Demonstration (Experiential Learning)* • This is where learners can show that they have understood what they have learned so far in the lesson. *Consolidation (Reflection & Discussion)* • In the final stage of the cycle, students can consolidate their learning through meaningful review.

The second layer defines the need for a theoretical basis for implementing the accelerated learning models. There is a lack of research focused on understanding the theoretical underpinnings of accelerated learning within the literature. Without this basis, it would be challenging to determine which instructional strategies would support accelerating learning. Through the literature search and the validation approach described in the following section, learning theories were identified as the underlying reasoning and support of the accelerated learning models (Table 2). The learning theories provide guidelines and principles recommended to facilitate learning. Future research should conduct analyses to provide empirical support for the alignment of learning theories and accelerated learning models.

Table 2. Proposed learning theories that support accelerated learning models.

Theoretical Learning Foundation of Accelerated Learning
• Constructivism • Experiential Learning • Zone of Proximal Development • Cognitivism • Cognitive Load Theory • Schema Theory • Scaffolding Theory • Expertise

The third layer determines the instructional strategies used within the game for training. These instructional strategies should have a theoretical basis while also supporting empirical research regarding their effectiveness in accelerating learning. Instructional strategies will vary depending on the concepts taught and expected training outcomes. A general list of instructional strategies shown to be effective for training with games is presented here, but this is not fully exhaustive (Table 3). Future research should expand this list and focus on determining the effectiveness of accelerating learning by utilizing and expanding the LM-GM framework (Arnab et al., 2014).

Table 3. List of instructional strategies gathered from the learning and training literature for game-based training.

Empirically supported instructional strategies for game-based training		
Role-play	Collaboration	Tailored experiences
Timely feedback	Competition	Increasing challenges
Expert-informed feedback	Experimentation	Problem-based scenarios
Time pressure	Reflection	Novel scenarios
Discrete decision-making	Explanation	Real-world scenarios
Adapting content	Consequences of decisions	Leaderboards
Scaffolding	Continuous learner assessment	Badges
Revealing hints	Multi-modal content representation	Gamification
Task variety	Narrative stories	
Peer discussion	Social activity	

The fourth layer leverages the information of the other three to generate game features. These game features may be based on prior research or novel ways of presenting content and allowing users to interact with the game. Game features should allow users to practice skills, support reinforcement, and aid retention. Understanding the users' demographics and taking a creative approach to determining which of these features are developed and implemented will facilitate engagement and motivation. Future research should begin to determine the level of effectiveness of each game feature in achieving accelerated learning for knowledge (e.g., procedural) and skill types (e.g., decision-making).

The fifth layer is the learning and training content portrayed through the game features. The content should reflect real-world context while adhering to pedagogical and game-based training principles. Conducting content domain and level analyses will help define the content used for the game and the order it is revealed. The game should have clear learning objectives or training outcomes to be achieved so the user understands the goal for the game and each level. This will help the user develop an awareness of what will be learned and how objectives or outcomes are related. The organization of the content and the way it is conveyed to the user will be critical in facilitating accelerated learning. Future research should determine the most effective way of organizing content and exposing users to accelerate learning.

Use Case Example

A simple use case example is provided to illustrate the application of the accelerated learning framework for game-based training design. The use case will discuss each component of the framework and how it can be used to choose instructional strategies for implementation through game features and content. The end-users and context are U.S. Marine Corps (USMC) squads training tactical decision-making skills within urban operations. Through a needs analysis, it was identified that USMC squads would benefit from a supplemental cognitive-based training solution to develop and practice squad leader decision-making skills.

Context

The impetus for this research initiative was to design a game to increase cognitive agility in support of strategic and tactical decision-making training for military operations on urbanized terrain (MOUT) conducted by USMC squads. MOUTs are the range of operations planned or conducted in areas dominated by complex human-made terrain, the supporting infrastructure, and the density of the population (MCRP 12-10B.1, 2018). As operations move further into urbanized terrains, it brings with it challenges that exponentially complicate decisive planning and action. The USMC's learning philosophy seeks to create a culture of continuous learning and professional competence that yields adaptive leaders capable of successfully conducting maneuver warfare in complex, uncertain, and chaotic environments. "Every Marine is a leader" is a USMC training motto. They have stressed the importance of rapidly developing leadership skills across all small unit team members to increase combat readiness, address prioritized capability gaps, and enable combat adaptation. Marines train to be prepared for two rank levels above their current position in preparation for uncertainties during operations, but not every Marine has the drive or experience to be a leader. Therefore, a game-based training approach was proposed to implement accelerated learning principles and strategies within the context of real-world combat tactics, techniques, and procedures (TTPs) to motivate, engage, and rapidly prepare Marines to think, act and perform like experienced leaders.

Game design

Marine squads train together, and everyone works with at least one other person. Considering Meier's (2000) third principle (i.e., Collaboration aids learning) and Marine's current training approach, initial ideas may be to develop a multiplayer game that involves cooperative tasks or working together to solve a problem. Next, examining the learning theories, one aspect of constructivism states that learning is a social activity. The research literature indicates that social activities are effective and provides empirical evidence for instructional strategies, such as peer discussion. Considering these components, a game feature should involve cooperative tasks that require collaboration among peers to solve a problem. To motivate, engage, and facilitate training transfer, the context of these problem-based scenarios must be relevant to a defined topic within the Marine squad's urban operations training, such as deciding which offensive maneuver tactic to implement to avoid an ambush. This process can be repeated to develop a full game concept. There is much more to a serious game's design and development process, including, in this case, substantially greater application of accelerated learning principles but generating the game concept through this framework will theoretically result in accelerated learning.

Table 4. Sample results of implementing the accelerating learning framework for game design

Accelerated Learning Principle	**Learning Theory**	**Instructional Strategy**	**Game Features**	**Learning Context**
Collaboration aids learning; learning is better within a social context, and we often learn in collaboration with peers rather than in isolation	Constructivism – Learning is a social activity	Peer discussion	- Multiplayer game - Cooperative tasks that require learners to work together to solve problems	- Learning context is urban operations - Learning objective: Understand which tactics to use during offensive operations - A task is to decide an offensive maneuver tactic to avoid an ambush on the way to a staging area

FRAMEWORK VALIDATION

Currently, one approach was used, and a second was proposed, to validate the accelerated learning framework. A digital hybrid card sorting task called upon experts in learning theories and cognitive science to evaluate the framework's theoretical and pedagogical fit and structural components. Proposed for further validation is an evaluation within a real-world context to determine the effectiveness of the framework's application within an initial domain. Follow on evaluations within other contexts and domains will facilitate the acquisition of empirical evidence to support the framework's generalizability.

Hybrid Card Sorting Task

Experts with learning theory, instructional design, and cognitive science backgrounds were recruited to review and modify the framework using a digital unmoderated hybrid card sorting task. The goal for the hybrid card sorting task was to establish a theoretical basis of accelerated learning from which instructional strategies could be recommended for effective game-based training. Informed by the literature review, three levels of digital cards were generated: 1) accelerated learning principles and guidelines, 2) learning theories and guidelines, and 3) instructional strategies emphasizing serious games and decision-making. The digital cards were created in an electronic spreadsheet to facilitate organization, allow duplicates of the cards to be created as needed, and allow experts to conduct the task remotely. An initial draft of the game features and user flow was conceptualized and shared with the experts to provide anchor headings for aligning all three levels of the cards. Experts first worked alone, leveraging their expertise to sort all cards. The hybrid aspect of the task meant that although cards were provided with the previously described content, the experts were allowed to create more as they saw fit. Once completed, a researcher conducted a comparative analysis to identify discrepancies among the experts' sorting outputs. Next, discussions among experts were moderated by the researcher to reach a consensus on each item in disagreement. Results of this task were used to inform and restructure the accelerated learning framework. This task also helped establish game concepts that were informed by the literature as potential features of the final game design. Moving forward, this digital card sorting task methodology can be used to evaluate and refine game features throughout the iterative development cycle.

Effectiveness Evaluation

The framework is in its inception and must be further validated through an empirical evaluation. First, the game will need to be developed. The framework can be modified throughout the development based on iterative usability, user experience, and initial testing of the game features to meet desired training outcomes. Then, a study will be proposed to evaluate the impact of utilizing the game for supplementing training of squad leader decision-making within urbanized terrain operations. Multiple approaches can be taken to infer the game's effectiveness, such as controlling the game usage between groups or comparing the past performance of previous course graduates to new trainees utilizing the game. Ultimately, there needs to be a transfer of decision-making skills and knowledge to the real world. Therefore, part of the study proposes to evaluate the impact on field training exercises with the expectation that time spent in the field training will focus more on executing the training TTPs, rather than discussing fundamentals that should have been previously learned. This process can be repeated within a different context and domain (e.g., medical training) to capture the framework's generalizability and inform refinement.

CONCLUSION

Accelerated learning approaches can provide solutions to prepare the workforce for the challenges faced within complex tasking domains, such as warfighter squad leaders' MOUT decision-making. The literature has shown that leveraging serious digital games is effective for training, but more research is needed to determine how to implement them to accelerate skill acquisition. The effort presented generated a framework to guide the design of games in support of accelerated learning. The proposed framework builds upon and complements existing models and frameworks for designing serious games and evaluating accelerated learning. The framework components provide a structural approach to ensure all aspects of the game are backed by grounded learning theories, which inform the instructional strategies and game feature design. Critical to the game design is following best learning practices for content creation, organization, and delivery. Through the interplay among all proposed framework components, it is theorized that gameplay will result in accelerated learning. Initial validation of the framework was accomplished through an expert-driven hybrid card sorting task. Game development, and further validation through experimentation using the game, are recommended to gather empirical support for the framework. Suggested research areas related to each component of the proposed framework were provided. As further research implementing the new framework is conducted, robust recommendations will be developed to guide game-based training applications across domains.

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