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MediaLiterate: Engaging Middle Schoolers in Media Literacy and Digital Citizenship via Game-based Learning

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A. Significance

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C. Personnel

Sam von Gillern, *Principal Investigator, MVN* will be directed by PI von Gillern, who brings expertise in ELA education, ML, and DC and has managed research activities on an externally funded project from the NIH (FAIN: R44GM133273). von Gillern will be the director of grant activities. For project management activities, von Gillern will work closely with the Co-PIs. von Gillern will supervise all GRAs who will assist with subject matter expertise and data collection, analysis, and dissemination. von Gillern's other responsibilities will include serving as subject-matter-expert for the game ML and DC content, supervising participant recruitment, and providing input on game development and mechanics, drawing on his expertise on GBL.

Joseph Griffin, Co-PI, is Director of the Adroit Game Studio and will be responsible for all game development activities (e.g., development, iterative testing) and direct supervision of programmers and artists who work on the game. Since coming to MU, Griffin has collaborated on over $18 million in game-based learning research development work. Under Griffin, Adroit Studios has completed two large-scale IES and i3 serious game development projects and is currently working on a $2 million Dept of Ed grant to develop a game to assess social emotional development.

Noah Glaser, Co-PI, is an assistant professor at the University of Missouri's School of Information Science & Learning Technologies, where he is also the director of the Information Experience Lab. Noah primarily conducts design research to create learning interventions that use innovative technologies such as virtual reality, video games, mobile devices, and artificial intelligence. He is particularly known for his work on developing innovative, immersive learning systems for neurodiverse learners, and has conducted research using EEG and eye trackers to better understand how people learn and interact with technology.

William Romine, *Co-PI*, is Associate Professor and Director of Data Science for Education Laboratory at Wright State University is an applied quantitative researcher and will supervise all aspects of instrument management, data collection and analysis. Romine will work with Senior Personnel Griffin on accessing and analyzing the game logs for RQ4, and evaluator Hacker on sequential analysis.

Amy Lannin, Co-PI, is an Associate Professor of English Education and former MS teacher, has experience working with MS ELA teachers will provide input on the game design from a teacher perspective and design the teacher training for the feasibility and field tests (Goals 2 and 3). Lannin will also design the curriculum for the comparison group and facilitate teacher professional development on study purpose, methods, and curriculum.

The MU Office of Sponsored Programs and CEHD Office of Research Support will help administer *MVN*, and the CEHD's grant-experienced fiscal staff carefully track all expenditures and ensure that all agency-required reports are completed. The project will also benefit from the expertise of our assembled advisory board who were selected based upon their expertise in ML, SSR, DC, and GBL. The board will participate in semi-annual meetings and consult with project sub-teams align with their expertise. See Appendix C for support letters.

Douglas Hacker...

Post-Doctoral Fellow...

Project Coordinator...

Advisory Board. Our advisory board members are experts in...

1) Kurt Squire – Sam to write
2) Sarah McGrew – Sam to Write
3) Paul Mihailidis - Sam to Write
4) Mike Ribble - Sam to Write
5) James Laffey – Joe to Write

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Intro text.

1) **University of Missouri (MU).** MU...
2) **College of Education (MizzouEd)**. MU..

3) 3rd item???

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1. ***Nureva Span System.***

2. ***eMINTS National Center*. eMINTS...**

3. ***iSchool Member*.**

Partnership with Schools. MU is a land-grant institution...

1. **Missouri Partnership for Educational Renewal (MPER)**. MPER...

2. **Kerry Townsend (CPS)?**

A1. Overview

University of Missouri College of Education and Human Development (CEHD) faculty and the college's Adroit Gaming Studio propose, "*MediaLiterate: Engaging Middle Schoolers in Media Literacy and Digital Citizenship via Game-based Learning,*" an educational game that focuses on developing skills in three areas key to students' success in our digital world: a) media literacy, b) socio-scientific reasoning, and c) digital citizenship. Our project addresses **Absolute Priorities 1** (Demonstrates a Rationale) and **3** (Equity in STEM) & **Competitive Priority 1** (Equity in Student Access).

Media literacy (ML), socio-scientific reasoning (SSR), and digital citizenship (DC) are critical for understanding the complexity of socio-scientific issues (SSIs) and parsing fact from fiction in our media-saturated world. This project focuses on helping students become informed, thoughtful, and active citizens. We address these needs by developing an engaging educational game (aka a "serious" game), *Mission Vita Nova* (*MVN)*, to promote students' ML, SSR, and DC learning. Game design will be based on transformational play (Barab, 2010), which engages players in contexts that are socially and academically relevant. We will measure impact using field-tests in 50 middle-school (MS) classrooms selected from Missouri's lowest performing districts with underserved students through analyzing game log data to determine which game features are most beneficial and testing the game efficacy through a cluster random assignment.

The goals of our project are: 1) develop a fully functioning prototype of *MVN* and supporting documents and training; 2) examine the feasibility of implementing *MVN* to support underserved students to learn ML, SSR, and DC skills, and 3) conduct research on the impact of *MVN* on learner's ML, SSR, and DC skills, and teachers' perceptions of *MVN's* implementation.

Our research questions are as follows:
RQ1. To what extent does *MVN* promote ML learning for students, as compared to underserved students in a comparison group?
RQ2. To what extent does *MVN* promote SSR learning for students, as compared to students in a comparison group?
RQ3. To what extent does *MVN* promote DC learning for students, as compared to students in a comparison group?
RQ4. How do participants use *MVN* to learn ML, SSR, and DC?
RQ5. What are the teachers' perspectives on the ease of implementation of using *MVN* in classrooms and its ability to promote ML, SSR, and DC for students?

A2. Significance of the Proposed Project

A2i. Conceptual Framework: ML, SSR, and DC are Critical to Society. Due to the massive increase and ubiquity of digital information resources, there are persistent calls for our K-12 students to develop proficiency in ML (Bulger & Davidson, 2018; Herold, 2016). The National Association for Media Literacy Education defines ML as the "ability to access, analyze, evaluate, create, and act using all forms of communication…[which] empowers people to be critical thinkers and makers, effective communicators, and active citizens" (NAMLE, n.d.). Thus, it is critical to develop students' ML and reasoning skills to empower them to successfully understand, navigate, and be informed participants in society (Rasi et al., 2019). Adolescents have substantial difficulties evaluating the credibility of media messages, but children can develop media evaluation and reasoning skills via educational programming (McGrew, 2020).

SSR involves critically examining socio-scientific issues (SSIs) (Sadler et al., 2011). SSR has been parametrized as a progression which is centered on the ability to recognize that multiple perspectives are involved in the negotiation of SSIs (Romine et al., 2017). This ability to take multiple perspectives buttresses an appreciation that SSIs are always subject to ongoing inquiry and the ability to negotiate biases associated with different types of information helps students develop critical perspectives on SSIs at both local and global levels (Simonneaux & Simonneaux, 2011). SSR aligns with and complements ML in that they both help students evaluate media messages to support their understanding of important social issues.

DC involves using technology to participate in productive public discourse and engage with diverse people and viewpoints respectfully online (ISTE, n.d.). Given that much modern civic change is mediated through digital technology, it is critical that students develop their DC to help them become responsible, informed, and active citizens, which can be facilitated through educational programming (Hobbs et al., 2013; Jenkins et al., 2020).

This project recognizes the connection between ML, SSR, and DC. ML and SSR both aim to help people critically evaluate media messages, including those of civic and scientific importance. Further, both ML and SSR contribute to DC as analyzing and evaluating the credibility of civic media messages (ML and SSR) is critical to becoming a well-informed citizen who can thoughtfully participate in digital public discourse and advocate for positive change (DC). Within the current digital age, ML, SSR, and DC are critical to full participation in modern society (Mihailidis & Thevenin, 2013; Mossberger, 2009; Romine et al., 2017).

A3. Promising New Strategies

A3i. Rationale and Research Base. Our design leverages game-based-learning (GBL) towards developing ML, SSR, and DC knowledge and skills. See Appendix G for full Logic Model.

A3ia. Game-Based Learning Strategies Provide Methods to Engage All Learners. Digital gameplay has become prevalent in our society, and over 90% of adolescents in the U.S. play video games (NPD Group, 2020). A key aspect of GBL is that games promote motivation and engagement with educational content (Gee, 2007; Hamari et al., 2016), which in turn impacts learning (Hattie, 2009). This includes diverse learners in mathematics (Carr, 2012), science (Sung & Hwang, 2013), literacy (Gee, 2007), and social studies (Hwang et al., 2015). ML, SSR, and DC, however, are three topics that have been underexplored with GBL.

A3ib. Transformational Play. Transformational play (TP) (Barab et al., 2009) is a design theory for promoting learning within games and focuses on how curriculum and game-designers can put players into virtual worlds that allow them to enact role-specific identities, one in which they use real-world curricular content to solve problem-based issues. The player into the role of a curricular-based protagonist who makes consequential decisions that further the game that. Our project will create a virtual world where players engage as an advocate for a small settlement's town council, who learns about ML and SSR to combat misinformation on Somnius, the Virtual Reality social media (SM) platform. Players will utilize their new skills to investigate media on SSR issues such as water pollution (ML & SSR) & advocate for community change (DC).

A3ic. ML, SSR, and DC Digital Game-Based-Learning. The effects of GBL ML, SSR, & DC are poorly understood. Existing GBL ML studies focus more on information literacy rather than on evaluating the content of messages, a key aspect of ML. Markey et al. (2008) studied a game called *Defense of Hidgeon* to promote information literacy skills; however, results focused on game design and not student learning. No GBL SSR games were identified in our review of the literature. While Chang et al. (2018) investigated SSR via an augmented reality app, it was not a game and it measured student learning attitudes, not learning skills or content. Tapingkae et al. (2018) found that a DC game could increase student motivation and reduce student anxiety related to learning DC, but they had a limited sample size (n=60) and measured student motivation and not learning gains. An engaging game for students to learn ML, SSR, and DC and an experiment to evaluate its learning efficacy would be a boon for GBL research.

A3id. Universal Design. *MVN*'s design and development (Goal 1, Years 1 -3) will adhere to the principles of Universal Design for Learning (UDL). UDL principles call for designing a product or environment so it can be accessed, used, and/or understood by all individuals regardless of age, ability, or disability. See Appendix J for specifics on implementing UDL in *MVN*.

A4. Exceptional Approach

Although there have been a few games that address ML, SSR, and DC (Hill, 2015; Markey et al., 2008; Markey et al., 2011; Tapingkae et al, 2018), *MVN* will be unique in two notable ways: 1) existing games largely focus on information literacy skills (e.g., accessing information) and less on evaluating information, and 2) this game blends ML, SSR, and DC concepts that students can use in everyday life as informed and active citizens.

A4i. Integration of ML with DC Skills. In *MVN*, players will be challenged to develop their ML, SSR, and DC abilities by engaging in authentic ML and SSR tasks (e.g., evaluating the credibility of media messages) and responsibly sharing messages and advocating for positive community change (DC). To achieve these goals, students will assume the role of a town advocate who helps users understand how to evaluate media messages on issues (e.g., water pollution to determine credibility and creates media as an informed citizen advocating for change

A4ii. Focus on ML, SSR, and DC Content and Skills Align with Educational Standards. *MVN* will engage learners in ML, SSR, and DC skills and processes that align a variety of standards, including Common Core ELA Standards, ISTE (2016) Standards for Students, RAND

Corporation's Media Literacy Standards (Huguet et al., 2021), and Next Generation Science Standards (NGSS). This alignment of ML, SSR, and DC game content with educational standards provides a means to address important content in an engaging way through GBL with *MVN*. See specific standards in Table 2.

B. Research Plan

B1. Goals, Objectives, and Measures

Table 1. Project Goals, Objectives, and Measures

Development and Iteration Phase (Years 1-3)	
Goal 1 – Develop a full prototype of *MVN*	
Objectives	**Measures***
1.1 Iteratively design and develop the five units of *MVN* game, and associated teacher training 1.2 Collect feedback on iteratively developed game products 1.3 Develop structures to collect in-game analytics and do sequential analysis to measure student engagement and learning	Project records; Teacher feedback on game units and teacher training; Student UX testing on game units; Advisory board feedback on game in-game analytics produced and eye-tracking data
Feasibility Study Phase (Year 4)	
Goal 2 – Examine the feasibility of implementing *MVN*	
2.1 Implement *MVN* in two classes to determine feasibility	Eye-tracking with student subset; teacher interviews; formative gameplay analytics; classroom observations
Field Test Study Phase (Year 5)	
Goal 3 – Conduct research on the impact of *MVN*	
3.1 Implement *MVN* and accompanying support materials in 25 classrooms; business as usual ML instruction in 25 comparison classrooms	25 classrooms use *MVN* & 25 as a comparison-all from Missouri's lowest performing districts
3.2 Research data gathered in 50 field test classrooms	ML, SSR, and DC pre/post measures; teacher surveys and focus groups; game play log data (i.e., process data)
3.3 Dissemination of *MVN* products and research results via websites, ELA and gaming conferences and journals	Dissemination activities as described in *Section B4*

* For further details on measures, see *Section C. Evaluation Plan.*

B2. Description of *MVN*

B2i. Standards Addressed

Table 2. Learning Objectives Mapped to Standards

Concepts	Media Literacy & Socio-Scientific Reasoning	Digital Citizenship
Unit 1	**Game Tutorial**	
Unit 2	CCSS.ELA-Literacy.RI.7.6 - Determine an author's point of view or purpose CCSS.ELA-Literacy.RI.7.9 - Analyze authors' approaches to presenting media	ISTE - Students explore local and global issues
Unit 3	RAND ML Standards -Identify trustworthy information sources - Seek complete understanding of facts	ISTE - Students plan and employ effective research strategies
Unit 4	CCSS.ELA-Literacy.RI.7.8 - Trace and evaluate the argument and specific claims in a text RAND ML - Evaluate the credibility of information and soundness of arguments NGSS – Compare and critique two arguments on the same topic	ISTE - Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions
Unit 5	RAND ML - Responsible engagement to counter truth decay NGSS – Construct argument supported by empirical evidence and scientific reasoning	ISTE - Students publish content that customizes the message and medium for their intended audiences.

Key: CCSS=Common Core State Standards, ISTE=International Society for Technology in Education, NGSS-Next Generation Science Standards

B2ii. Game Overview, Characters and Settings. In MVN, middle-school students will engage in a narrative-driven serious game that tells the story of a newly settled planet in the digital age. MVN aims to help its users develop their ML skills, so they can become critical consumers and productive disseminators of news and civic media (see Appendix J4 for screenshots of gameplay based on our current prototype). During the game, players take on two primary roles as the digital advocate for their settlement: evaluator and creator of YuMes (hologram posts) on Somnius (a new futuristic SM platform). First, the player assumes the role of an advocate for the town council of a small settlement. As advocate they are in charge learning about key aspects of ML and SSR in order to evaulate what various groups in their town are saying about civic issues. The second player role is as a creator of YuMes on the Somnius platform. The gameplay loop is such that after the Advocate critically analyzes and evaluates media messages related to the civic topics such as mining or water pollution; they then create new media to share their perspective and ideas for productive community action (see Appendix J for more details on Game Plan, Setting, and Characters). This cycle of evaluation followed by creation will occur five times (once for each unit) and each time players will encounter more challenging content to strengthen their ML, SSR, and DC skills. Table 2 maps educational standards to each unit.

B2iii. Game Mechanics.

B2iiia. Pedagogical Agents (PAs). We will implement a PA in *MVN* designed to offer ondemand real-time assistance/coaching throughout the game on ML, SSR, and DC. Research on PAs shows their potential to improve a game's impact (André et al., 1998), and that using agents can enhance problem solving skills (Lester et al., 1997) and improve learning when compared to text-only and voice-only conditions (Atkinson, 2002). The agent's development will follow established guidelines for animated agents' character and behaviors (Lester et al., 1997) (e.g., believability, responsiveness, and reinforcement of user performance).

B2iiib. Real-Time Feedback. Being able to provide frequent and direct feedback is one way that digital games have an advantage over traditional forms of instruction. **S**tudies demonstrate that feedback in digital games can improve learning outcomes (Narcisse, 2013; Kiili et al., 2014). Providing real-time feedback in *MVN* will provide players with information regarding performance and progression toward the learning objectives identified in Table 2. Non-player characters in the game will provide feedback on player's choices and work throughout the game. Feedback from pedagogical agents will help players continue productively in their play (e.g., during a media analysis task, suggesting the player check the message creator's credentials).

B3. Participant Recruitment

Participants for Years 1 – 4 (UX and feasibility testing) will come from Columbia Public Schools (CPS). CPS serves 16,700 students; 32% are students of color, 36% receive free/reduced lunch, and 14% receive special education. CPS project liaison (K. Townsend, Director of Media Services for CPS; see Appendix C, Support Letters) will help coordinate with school-based participants and provide feedback on materials. For UX testing, Townsend will identify underserved students to participate. For the feasibility study (Year 4), Townsend will help recruit two MS ELA teachers and their classes to implement the game & provide supportive materials.

For the field-test in Year 5, we will recruit a total of 50 classrooms (resulting in a sample size of around 1250 students) from the lowest performing districts in Missouri. (See Appendix J). As is the case nationally and statewide, these low-performing districts serve high concentrations of underserved student populations (e.g., high percentages of low-SES and minority students). With the support our College's MPER (Missouri Partnership for Educational Renewal network (see Letters of Support) we will contact district superintendents and ELA coordinators starting with the top 10 of the list and work our way down the list in order to reach our needed goal of 25 treatment and 25 comparison classrooms. For any district that expresses interest, we will recruit 6th, 7th and 8th grade ELA teachers who include ML related content in their classes. Twenty-five of these 50 classrooms/teachers will be randomly assigned to be in the treatment/game condition and the other 25 be in the comparison (ML instruction as usual) condition. For all project phases, teachers will receive stipends and participating schools will receive an incentive and pay for substitute teachers so recruits can participate in project training, which will address project aims, teacher and student roles, curricula, and the assessment plan

B4. Evaluation and Analysis

B4i. Outcome Measures. To meet WWC evidence standards without reservations, studies must include valid and reliable outcome measures for SSR, ML, and DC. These outcomes will be assessed via measures that were developed and validated in previous research (Romine et al., 2016; Vraga et al. 2015; Jones & Mitchell, 2016). The SSR assessment comprises ten 2-tiered multiple-choice items embedded within a scenario asking students to negotiate an SSI. Given our focus on issues such as water pollution and conservation, we will use the Branville Bay scenario (reliability = 0.63) (Romine et al., 2016). To measure ML, we will use the *Value for ML* (4 items, reliability = 0.83) and *Self-perceived ML* (3 items, reliability = 0.82) scales from Study 1 in Vraga et al. (2015). The items in *Value for ML* get at the value students place on sources of information which goes beyond their own personal use. Items in *Self-perceived ML* get at the extent to which students believe they are media literate. To assess DC, we will use the *Online Civic Engagement* subcale (4 items, reliability = 0.7) which measure students' use of online media for community improvement (Jones & Mitchell, 2016). Additionally, pre-test student surveys request student demographic information. See Appendix J for the specific questions included in these measures.

Teachers will choose when in the school year they implement *MVN*, with the constraint that they will implement the comparison curriculum in their other classes at the same time. Data collection procedures and timing will be the same for treatment and comparison students.

B4ii. Experimental Approach. The approach to the impact analysis aligns with the randomized block design stratified by teacher, using a 2-level regression model where students (level 1) are nested within classrooms (level 2) and includes a series of dummy variables for the stratification variable (teachers). Impacts will be estimated using an intent-to-treat analysis to compare treatment and comparison group means on: (1) SSR, (2) ML, and (3) DC. Baseline measures of the outcomes will be included in the analytic model to improve precision and increase power. Given our hypothesis that SSR and ML support DC, baseline scores for SSR will be included as covariates for the outcomes of ML and DC and baseline scores for ML will be included as covariates for the outcomes of SSR and DC. Potential additional student-level covariates to be included in the models are gender, age at baseline, and race/ethnicity. See Appendix J for the statistical model describing the analytic approach.

Students with missing outcome data will be counted as leavers, and students joining classrooms after random assignment will be counted as joiners and will not be included in the analysis. We expect to have high response rates for the baseline surveys which will provide pre-test and covariate data. In the event of missing covariate data, we will use the dummy variable method implemented in accordance with WWC evidence standards. We will only rely on one outcome measure per outcome domain and will not need to adjust for multiple comparisons for SSR and CE. The Benjamini-Hochberg procedure will be used to correct for Type 1 error inflation in evaluation of the two ML subscales.

For our power analysis, under realistic conservative assumptions (a student-level uniform attrition rate of 20%, a two-tailed Type 1 error rate of 0.05, a Type 2 error rate of 0.2, an intraclass correlation of 0.2, and that the pre-tests and demographic variables explain 70% of the variance in the outcome), this design expects to yield a minimum detectable effect size of 0.22.

B5. Management Plan and Timeline

B5ii. Timeline (Table 3).

Table 3. Project Timeline

Year 1	Year 2	Year 3	Year 4	Year 5
Goal 1: Develop fully functioning game prototype			G2: Feasibility	G3: Field Trial/Research
Overall game Design & Unit 1	Units 2 and 3	Units 4 & 5, & teacher training materials		
Iterative design reviews, UX testing, and revisions				

	Game log design, log analysis tests & dissemination activities begin			
	Recruit Feasibility & Field Trial Teachers/Classrooms			
		Yr 4: Feasibility trial in 2 classrooms w/data collection		Field trial 50 classes
				Data analyses & Dissemination

In Year 1, we will start with storyboarding and fleshing out our mapping of desired learning standards to game mechanics. The design team will use the Learning Mechanics-Game Mechanics (LM-GM) framework (Arnab et al., 2015) to link pedagogical practice to concrete game mechanics directly related to a player's actions. Next, these established LM-GMs will be embedded within the gameplay and tested for engagement and efficacy. The outcome of the first year will be a working game demo showcasing one unit with the core game mechanics as well as analysis of user experience. In Years 2 & 3, we will focus development on core content of the game resulting in a complete version of the game, which will be tested in Year 4 for feasibility in classrooms. See Section C- Evaluation – for details on each game development cycle during UX, feasibility and field testing.

B6. Feedback and Continuous Improvement

The project team will guide continuous feedback and improvement using an iterative design process. During Years 1 – 3, *MVN* will be reviewed by experts and teachers and tested with students. Formative data will be collected to inform game revision. Data sources will include teacher interviews, student game testing and post interviews, advisory board input, and sequential analysis. Teachers and students from partner schools will be recruited for interviews conducted by team members von Gillern, Lannin, and Griffin based on a stratified sample based on school type (urban, suburban, rural) to promote diverse perspectives. This process will be repeated annually through Year 4 feasibility testing. After feasibility testing, we will review the data and determine revisions for Year 5 to improve the game and develop field materials.

To enable hosting, maintenance, and continuous improvement of GBL projects in between external funding, SISLT and the CEHD have founded Adroit Studios. All *MVN* materials will be made available through Adroit's distribution infrastructure including: user registration system; system download, install, and testing scripts; as well as the extensive logging pipeline and teacher dashboard. All infrastructure is maintained by Adroit Studios to support the continuous distribution and improvement of their games. After this project's work is completed, the team will pursue future submissions to the EIR mid-phase program as well as the SBIR and STTR programs. We will ultimately utilize MU's Technology Transfer Office specializing in disseminating research-based technology out to the community at large.

B7. Broad Dissemination

We will disseminate our findings with both research- and practitioner-focused outlets including the following journals: Journal of Literacy Research, Educational Technology Research and Development, The International Journal of Game-Based Learning (IJGBL), Computers and Education, and Journal of Adolescent and Adult Literacy. We will also submit proposals to both researcher and practitioner conferences (e.g., Literacy Research Association, American Educational Research Association, National Council for Teachers of English, Ed Media, and Foundation for Digital Games) beginning in Year 3 with preliminary findings.

Additionally, we will share our findings with policy makers, including Missouri's Department of Elementary and Secondary Education (DESE). We will also leverage our partnership with MPER to share our findings with schools and districts around the state.

C. Project Evaluation

Co-PI Romine will work with the PI and other senior personnel and use the research design described below to evaluate the impact of *MVN* on students' ML, SSR, and DC learning in Year 5. This includes validation of the assessments for our cohort and carrying out the cluster random assignment design. In addition, Douglas Hacker, Ph.D. will serve as the external evaluator for *MVN* (see CV and letter, Appendices B &C). Dr. Hacker has over 20 years of experience in school and program evaluation. He has evaluated projects including serious games, classroom instructional programs, schoolwide program implementation, and district-wide restructuring. He will produce annual reports addressing these areas and provide a summative report at the end of the project and make annual onsite or online visits to MU for a deep review of progress. The following sections describe the design and evaluation activities for each project goal.

C1. Design Overview

Years 1-3 will be used for iterative game development. In year 4 we will do a two-classroom feasibility study. In year 5, we will field-test the game using a cluster randomized trial with a pre-post design with 25 ELA classes in the treatment condition, and 25 in the comparison. Only schools with sufficient computer resources will be included in the study. See Sections A1 and B4 for a summary of the research questions and experimental design, respectively.

C1i. Research Question Measures. For **RQs 1 – 3 (ML, SSR, and DC)**, we will use existing validated measures for pre- and post-testing data for ML. SSR, and DC (See Section B4).

To answer ***RQ4 (Usage of Game),*** we will use contextualized game play logs. The game will have an extensive logging system that captures various aspects of players' status and interactions (e.g., each user action, time spent at each place in the game). For instance, "Player P is on task T" or "Player P is clicking on object O." These data will be used to identify patterns in gameplay across users and any relationships between these patterns and learning outcomes. Patterns of gameplay will be identified through both visual inspection of the data and through the implementation of unsupervised machine learning approaches such as latent class analysis (Collins & Lanza, 2010) and hierarchical clustering (Theodoridis & Koutroumbas, 2001).

For ***RQ5 (Teacher Perceptions)***. We will use teacher focus groups and a survey to gather data on the experimental group teachers' perceptions of the ease of implementing the game in classrooms, their observations about students' game usage, and perceptions on the game's impact on learning. Survey items will be from subscales of the Teacher Technology Integration Scale (TTIS); specifically, the instruction purposes, facilitation of student technology use, and perceived benefits of technology in the classroom. Vannetta and Banister (2009) validated the TTIS and found the scales to be reliable (reliability > .84).

von Gillern and Lannin will hold four teacher focus groups across the state to include all 25 treatment group teachers. Each will use a semi-structured protocol to gather data on game implementation, its value, and observations student gameplay.

C1ii. Iterative Game Development Formative Measures.*MVN* will be developed using an iterative design strategy during Years 1–4. After each game unit is developed (Goal 1), we will conduct UX (user experience) tests with students (recruited from local district CPS). During student UX session observations, custom checklists are created to make note of specific player behaviors (e.g., "Did the player talk with the mentor character prior to undertaking the task?

Y/N", "how far in gameplay did the user get?"). Eye-tracking data will be collected for both UX and feasibility testing to understand how player attention is focused during game play (Zhu et al., 2021). With these data, plus gameplay logs, we can develop an understanding of students' focus and behaviors to improve future iterations of the game. We will use Gaze Mapping from iMotions which we have experience with. See more on formative measures and data collection details in C2i and C2ii.

C2. Develop a Full Prototype of *MVN* (Goal 1) Formative Evaluation

During Goal 1 activities (develop prototype), formative evaluation activities will concentrate on user gameplay experience (UX): (1) accessibility, (2) understandability, (3) alignment with curricular objectives, and (4) user enjoyment. This cycle's objectives will be met when there is a fully functioning *MVN* prototype.

C2i. Game Development & Formative Evaluation. Procedures for developing the initial prototype and iterating on the initial prototype will include the following steps.

1. ***Development of basic elements of game***. **Basic game element development** (game environments, characters, ML, SSR, and DC content and mechanics) will start immediately via initial prototyping, feedback gathering, & UX testing. Modifications will occur based on Step 2.
2. ***Pre-Assessment of SSR, ML, SSR, and DC instruction***. We will conduct a procedural task analysis of ML, SSR and DC tasks with our Advisory Board and a teacher liaison, as well as review existing ML-related instruction from teacher(s) from CPS. These data will provide a pre-intervention benchmark on how they approach ML, SSR, and DC instruction with students as well as comparative data relative to what the literature show. We will document these benchmark results for comparison with later game iterations and student interactions.
3. ***Initial prototype of game***. We will create an initial prototype that builds on the basic game elements in (1) above and implements player scaffolding and supports discovered in (2). This initial prototype will also include the development and integration of game features and mechanics that will support game log and analytics data. The prototype will undergo the following reviews and be iterated upon for each unit of the game. **3a. Stakeholder and expert review of prototype** – Advisory Board will meet with grant personnel and provide reviews of the prototype. **Data collected** will be collected through feedback and marked-up documents with Advisory Board members as well as meeting notes and conversations. **3b. Student & teacher UX testing of prototype**: Student players will be brought in for formative UX testing of the initial prototype, and teachers will be interviewed as they do a game walk-through with project personnel. We will recruit these teachers based on existing partnerships. These teachers will suggest students for prototype testing. **Data collected** will include observation protocols from student testing, student post interviews, short Likert scale satisfaction surveys, student eye-tracking data, game logs and teacher walk-through interviews. Data-driven iterations will be made until MS students and teachers report that the game is both engaging and usable. As prototyping begins on game units 4 and 5, team members will also begin creating teacher documentation that will also be reviewed by teachers for usefulness and understandability.

C2ii. Formative Data Analysis Plan. Data from the *MVN* UX testing will be collected multiple times for each of the *MVN* prototype iterations (we anticipate five–one for each unit). We will summarize each observation protocol and then synthesize them across the protocol results, summarize interview data, categorize the feedback from meetings, notes on the design document, feedback ratings, and conduct a content analysis to determine patterns and themes across the data sources. We will use deductive analysis, starting with the categories on the feedback form while also identifying emergent data categories. We will also summarize the eye tracking and game log data to inform our understanding of the other formative data sources. To enhance credibility, at least two researchers will independently analyze the data and then corroborate to determine consistency in the findings. The team will discuss inconsistencies and come to consensus regarding the salience of themes. Feedback will then be summarized into a checklist used to revise and refine prototype unit.

C3. Feasibility (Goal 2) Evaluation

For Goal 2–examine the feasibility of *MVN*- we will test all project products in two CPS classrooms. We will recruit a minimum of two CPS middle-school ELA teachers (~50 students) who will use the game with project personnel present for data collection and technical assistance.

C3i. Goal 2 Feasibility Implementation and Data Collection Activities.

1. ***Kick-Off Meeting.*** Teachers will be invited to attend a kick-off meeting at the MU. Here, we will (a) explain the purpose of the project and the feasibility trial, (b) provide a schedule for the gaming activities, (c) discuss data collection, (d) schedule fidelity checks, and (e) answer questions. Teachers will be asked to use *MVN* with at least one ELA class containing underserved students.
2. ***Student Informed Consent.*** During both the feasibility and field test, we will prepare a letter of consent for teachers to send home with their students. The letter will describe the GBL environment and the data that we will collect. If the parents allow their child to participate, they will sign and return the IRB form. Non-consenters may still play the game; however, we will not collect their data for our analyses and will be counted as attritors in the evaluation of efficacy for SSR, ML, and CE. All student data will be anonymized prior to data analysis.
3. ***Feasibility Trial.*** Teachers will implement *MVN* in ELA classes according to the schedule provided. We anticipate that *MVN* would be used for 30 minutes three times a week for five weeks in a MS ELA class. Project personnel will observe teachers and students using observation checklists. The teacher protocol will focus on how they introduce the game to the students, monitor students' uses, and provide help. The student protocol will focus on how they play each level of the game, which will be interpreted with game log data. Satisfaction survey questions adapted from the User Satisfaction Evaluation Questionnaire (Gil-Gómez et al., 2017) will be given to students. Students will engage in eye-tracking data collection to analyze how they experience *MVN*. We will adjust the user interface accordingly, if needed.
4. ***Usage Focus Group.*** A stratified sample (urban, suburban, & rural) of teachers and students will participate in focus groups held by von Gillern, Lannin, and Griffin to reflect on the feasibility, usability, and accessibility of *MVN*, aspects that they did and did not like, and what they think should be changed, such as game interface, feedback, and ease-of-use.
5. ***Revisions.*** Based on data collected and analyzed (see C3ii) we will determine what revisions are needed to improve the feasibility, usability, and accessibility of *MVN*.

C3ii. Feasibility Testing Data Analysis. Each data source (teacher and student observations, teacher focus groups, satisfaction survey) will be summarized by project personnel. For each data source, these summaries will be generated separately by two individuals, then compared and discussed, and then a final summary will be produced that resolves differences. Additionally, we will correlate eye-tracking and game log data to understand which game affordances get the most attention, and then determine if these "attention getting" affordances are where we want them to be in order to support engagement and learning. A project team and a selection of Advisory Board members will meet to interpret the summaries and compile a list of game revisions. These revisions will be implemented to produce the *MVN* version for Goal 3 – field testing.

C4. Field Test (Goal 3) Evaluation.

C4i. Field Test Activities

1. ***Kick-off meetings for MVN teachers***. Recruited teachers will be invited to attend a half-day kick-off meeting. At this meeting, we will use procedures revised from the kick-off meeting during the feasibility phase to (a) explain the purpose of the field test study; (b) allow teachers to play the game (c) provide a timeline for implementing *MVN* in classrooms and information on how to access support; and (d) set schedules for classroom observations.
2. ***Implementation of the intervention.*** Prior to *MVN* usage, teachers will follow the student informed consent process described above. Teachers will ensure that students utilize *MVN* in their classrooms. Teachers will be observed initially for fidelity (using observation form from feasibility). The field test will take 15 days of 30-minute sessions.
3. ***Field Test Data Collection.*** All students (treatment and comparison) will complete the pretest/post-test ML, SSR, and DC measures. All treatment group teachers will complete the TTIS scales and participate in a focus group after *MVN* gameplay has ended. Game logs will be collected automatically via gameplay.

C5. Field Testing Data Analysis Plan

RQ1-3. To what extent does *MVN* promote ML, SSR, and DC learning for underserved students, as compared to underserved students in a comparison group?

The field test will be conducted with 50 MS classrooms and collect data to answer all RQs. The field test objectives will be met when we have data that determines *MVN*'s potential for increasing ML, SSR, and DC relative to a comparison curriculum, understand which *MVN* features are most beneficial, and understand teachers' perspectives of the game and its ability to promote student ML, SSR, and DC. See Section B4 and Appendix J for details on methodology.

RQ4. How do participants use *MVN* to learn ML, SSR, and DC?

We will use game log data to answer RQ4. The students' log files will include data entries on processes such as mouse clicks and keystrokes and timestamps for these actions. Process data have been used to obtain information on massive open online courses (MOOCs, Deboer et al., 2014) and found to be related to students' performance on test items (Qiao & Jiao 2018), among other possible uses (Provasnik, 2021; Tang et al., 2021). The log data will be used to analyze participants' in-game behaviors and performance (e.g., how long do they stay at a particular place, or a set of places continuously that create a meaningful sequence). We will look at action sequences to find patterns (e.g., students tend to skip certain tasks) and use feature extraction methods to identify potentially meaningful constructs from the log data. Engagement data are critical in GBL as engagement impacts learning (Hattie, 2009). We will use the following engagement metrics: (a) number of minutes students stay in each place; (b) number of clicks, (c) their scores on ML, SSR, and DC tasks. Engagement data and features extracted will also be examined together with the ML, SSR, and DC learning measures. With further analysis (e.g., correlations), we can determine if the use of these affordances is positively related to the ML, SSR, and DC learning outcomes. Game log data will also be analyzed using sequential analyses methods (Jeong, 2003; Hacker et al., 2020) to provide data on how players move through the game (e.g., 20% of the time, a player moves from an interaction with the PA to a ML task), and if there are particular patterns of movement that are related to learning outcomes.

RQ5. What are the teachers' perspectives on the ease of implementation of using *MVN* in classrooms and its ability to promote ML, SSR, and DC for students?

We will use focus group and teacher survey data to answer RQ5. We will summarize the TTIS data and produce descriptive statistics for each subscale. Teacher focus groups will be transcribed and analyzed by two team members to identify themes regarding the game's ease of use, perceptions of student experience, their overall satisfaction with the field trial and any other input they have. To promote reliable results, researchers will meet before coding to review coding purposes, agree a coded unit of analysis, and generate a list of starting codes and definitions. They will then individually analyze a single focus group, meet to discuss results and differences and modify the code list and definitions and then proceed with the rest of the focus group coding. A project team will meet to go over the TTIS and focus group data together to provide qualitative data to supplement the TTIS quantitative data.

C. Personnel (2.5 pages)

- Solid paragraph for key players.
- Shorter paragraphs for advisory board members

D. Resources (1-1.5 pages)