CONCEPTUALIZING RTI IN 21ST-CENTURY SECONDARY SCIENCE CLASSROOMS: VIDEO GAMES' POTENTIAL TO PROVIDE TIERED SUPPORT AND PROGRESS MONITORING FOR STUDENTS WITH LEARNING DISABILITIES

Matthew T. Marino and Constance C. Beecher

Abstract. Secondary schools across the United States are adopting response to intervention (RTI) as a means to identify students with learning disabilities (LD) and provide tiered instructional interventions that benefit all students. The majority of current RTI research focuses on students with reading difficulties in elementary school classrooms. Recommendations for practice that stem from this empirical work are not generalizable to high school classrooms, where adolescents with LD experience unique learning challenges. This is especially true in secondary science classes, where an emphasis on complex vocabulary and sophisticated phenomenological investigations places added cognitive requirements on these students.

This article presents a foundation for conceptualizing the role of technology in RTI implementation at the secondary level. We examine how video games can enhance RTI instructional practices by providing multiple tiers of academic supports and real-time progress monitoring in secondary science classrooms. The article illustrates how evidence-based practices can be included in the games in a manner that increases intervention fidelity and assessment reliability. While this article focuses on science video games, we contend that there is considerable conceptual overlap among high school science, technology, engineering, and mathematics (STEM) courses that will allow for further expansion of this discussion. The article concludes with recommendations for future research.

MATTHEW T. MARINO, Ph.D., Teaching and Learning, Washington State University.
CONSTANCE C. BEECHER, doctoral candidate, Teaching and Learning, Washington State University.

States are increasingly turning to response to intervention (RTI) as a means of identification and intervention for students with learning difficulties (Berkeley, Bender, Peaster, & Saunders, 2009). Many authors (e.g., Gersten & Dimino, 2006; Mastropieri & Scruggs, 2005; Werts, Lambert, & Carpenter, 2009) have noted that there is a lack of consensus across the research community regarding the purpose and structure of RTI models. This is compounded at the secondary level due to a lack of empirical research that systematically examines the efficacy of RTI with adolescent learners (Brozo, 2010; Fuchs, Fuchs, & Compton, 2010; Vaughn et al., 2008).

The majority of RTI research to date has focused on remedial reading instruction for students in elementary schools, leaving researchers and practitioners with minimal information about how to implement RTI at the secondary level (Vaughn et al., 2010). In middle and high schools, adolescents face unique literacy challenges that substantively differ from elementary school expectations (Mastropieri & Scruggs, 2005). In addition, a lack of motivation and concerns about peer acceptance may act as barriers to effective implementation of intensive interventions at the secondary level (Fuchs et al., 2010).

Today's students are increasingly turning to technology as a means to gather information, communicate, and learn (Marino, 2010). In fact, preliminary research suggests that secondary students with disabilities often rely on technology more than their peers without disabilities (Lenhart et al., 2003). Unfortunately, current published RTI research has failed to account for the power of technology to provide universally designed instruction, improve implementation fidelity, enhance assessment and progress monitoring, increase motivation, and adjust instruction based on specific protocols that address students' individual learning needs.

In this article, we address this deficit in the literature by illustrating the conceptual relationships among video games that are designed for secondary students with learning disabilities (LD), or those at risk of learning failure, and the RTI model. Following an abridged discussion of the common principles of RTI, we describe content-specific challenges students with LD face in secondary science classes. We then illustrate how instruction and data collection mechanisms in a video game environment relate to a multi-tiered RTI model at the secondary level. The article concludes with recommendations for practice and areas for future research.

COMMON PRINCIPLES OF RTI

Barnes and Harlacher (2008) noted that RTI is generally defined as a series of principles that underlie the purpose of RTI and features that describe what RTI looks like in practice. Common principles of RTI include (a) a proactive educational process that emphasizes early preventive supports, (b) a systems-level approach for aligning curriculum with efficacious instruction in order to address individual student needs, and (c) the use of data-based decision making (Fuchs et al., 2010). Central to RTI is the use of universal screening to identify students who are at risk of academic failure so that remedial instruction can occur before the students experience prolonged periods of academic failure. Struggling students receive increasingly intensive levels of tiered interventions to remediate their areas of difficulty. While the number and purpose of tiers within the RTI model are subject to debate, each tiered approach includes a continuum of supports ranging from research-based instruction in general education classrooms to intensive small-group or individual instruction at more intensive levels (Werts et al., 2009).

The most common RTI model involves a three-tier approach (Barnes & Harlacher, 2008). Tier 1 includes all students in general education classrooms. Evidence-based instruction (i.e., based on empirical evidence supporting its effectiveness) is provided with fidelity in concert with benchmark assessments (Berkeley et al., 2009). Tier 2 includes students who do not achieve proficient levels of performance on tier 1 assessments. At tier 2, students receive more intensive remedial instruction in small groups that are differentiated by skill level. Explicit instruction is combined with increased assessment frequency, enhanced opportunities for participation in lessons, and immediate corrective feedback (Vaughn, Wanzek, Woodruff, & Linan-Thompson, 2007). Students who fail to make adequate progress with tier 2 interventions are moved to tier 3, where they receive more intensive small-group or one-to-one interventions. Further, student participation, fidelity checks, and assessment frequency increase compared to tier 2 (Barnes & Harlacher, 2008). In some instances, tier 3 represents a special education placement. Tier 3 has also has been conceived as the last step before special education referral.

There is considerable disparity between states and school districts within states regarding the number and purpose of tiers within the RTI model (Berkeley et al., 2009). Disagreement on the number of tier intervention levels extends to the process whereby students move from one tier to the next. There is also discontinuity surrounding (a) who is responsible for collecting assessment data, (b) who is responsible for tier placement decisions, and (c) which protocols should inform the process (Werts et al., 2009).

Three general protocol models are prevalent in the literature. In the problem-solving protocol, a team identifies the student's difficulty, plans an intervention, implements the intervention with fidelity, and evaluates the student's progress (Ikeda et al., 2002). In the standard protocol model, groups of students receive a prescribed evidence-based intervention (e.g., 30 minutes of phonics instruction) for a predetermined amount of time (Fuchs, Fuchs & Stecker, 2010). There are also hybrid models (e.g., Reschley, 2005), which incorporate aspects from both the problem-solving and the standard protocol model.

An additional concern when implementing RTI at the secondary level is its bifurcate focus on LD identification and instruction. To date, there have been strong arguments against RTI's validity as a means to identify LD at the secondary level. For example, Kavale, Kauffman, Bachmeier, and LeFever (2008) pointed out that using RTI as a means of LD identification does not provide compelling diagnostic evidence of processing deficits and unexpected school failure. Mastropieri and Scruggs (2005) offered similar criticisms, adding that inconsistencies in cutoff scores on standardized test screening measures across states add further confusion to the identification process. Fuchs et al. (2010) noted that the increased complexity of scheduling and service delivery inherent in secondary schools may necessitate a reconceptualization of RTI from serving as a means to identify students with LD to becoming a method of providing instructional interventions.

Given these compelling arguments and our personal experiences working in high schools, we will limit our discussion to the relationship between RTI and video games as a mechanism to provide tiered levels of instructional supports to students with LD and those at risk of learning failure. The use of RTI as a means to identify students with LD at the secondary level is beyond the scope of this article.

SECONDARY STUDENTS WITH LD STRUGGLE IN SCIENCE

Secondary science courses are rooted in inquiry. White and Frederiksen (1998) noted that scientific inquiry is a complex process where students pose questions, predict, experiment, model, and apply what they have learned. Students must actively engage both physically and mentally with scientific materials to effectively acquire the knowledge and skills necessary to promote science learning (Moriarty, 2007). McCleery and Tindal (1999) described three critical aspects of scientific literacy: (a) knowledge of factual information; (b) conceptual understandings of clusters of events and terminology that share common attributes (e.g., the concept that a gas incorporates substance, volume, and dispersion characteristics); and (c) a deep understanding of principles that reflect phenomenological relationships among concepts. Each of these aspects presents formidable barriers to students with LD.

Struggling learners fall further behind their peers as they enter secondary science classrooms because of a mismatch between students' needs and the curriculum (Mastropieri et al., 2006). These students often have misconceptions about scientific phenomena, which leads to a failure to obtain meaningful conceptual understandings of the inquiry process (Jacobson & Archodidou, 2000). In their seminal research on students with LD who were studying science, Dalton, Moroco, Tivnan, and Mead (1997) found that students with LD (a) have difficulty activating prior knowledge, (b) are reluctant to pose questions or conjectures, (c) are less likely than peers to have a systematic plan to approach problems, (d) struggle to take instructor feedback into account, (e) have difficulty making inferences during deductive and inductive reasoning processes, (f) seldom transfer knowledge across contexts, and (g) are less likely than peers to be aware of their metacognitive processes. Samsonov, Pederson, and Hill (2006) added that students with LD require substantive guidance to manage the extensive information and time restrictions imposed in secondary science classes.

Adolescents with LD and other learning difficulties face numerous institutional and content-specific barriers as they enter secondary-level science courses. These include rotating class schedules, limited instructional diversity, and science teachers with inadequate knowledge of effective practices for teaching students with LD (Alston, Bell, & Hampton, 2002; Mastropieri et al., 2006). As a result, students with LD often develop negative attitudes toward science as they enter middle school, where they encounter complex expository texts and other instructional materials that reduce their ability to access and comprehend scientific information (Lee & Erdogan, 2007). The National Assessment of Educational Progress (2007) science report, which indicated that 66% of students with disabilities scored below the basic level compared with 25% of their peers without disabilities, provides clear evidence that changes in the educational system are necessary to provide students with disabilities enhanced opportunities in science.

Research indicates that students with disabilities can be successful in science when they receive instruction that aligns with their unique learning needs and processing abilities. For example, Cawley, Hayden, Cade, and Baker-Kroczynski (2002), in a study examining the academic performance of 114 middle school students over the course of one school year, found that students with disabilities passed the district science exam at the same rate as their general education peers when instruction was provided by teachers who had received extensive training that focused on efficacious practices in inclusive science classrooms. In the subsequent sections, we highlight how technology can facilitate these practices in a secondary RTI model.

Including Technology in the RTI Model

Technology will continue to play an increasingly dominant role in education for the foreseeable future. It is, therefore, imperative that researchers and practitioners consider both its potential and its limitations as we continue to define a secondary-level RTI model.

Current research supports the notion that learning scaffolds included in technology-enhanced science curricular materials are beneficial for students with LD and other students who struggle with reading fluency, comprehension, and written expression. For example, Marino (2009) investigated the use of *Alien Rescue,* a technology-enhanced middle school astronomy curriculum that allows students to conduct virtual experiments while gathering scientific data from other planets in our solar system. Results from that and other follow-up studies (e.g., Liu & Bera, 2005) indicated that all students made statistically significant learning gains as a result of using the curriculum. In addition, struggling learners benefited more from tools that limited cognitive overload (e.g., databases that provided background knowledge) and tools that allowed them to conduct virtual experiments than did their proficiently reading peers. These types of technology-based supports should be considered during the conceptualization of secondary RTI tiered interventions. They can be seamlessly incorporated in educational video games.

Educational video games have the potential to transform the way students learn in the 21st century (U.S. Department of Education, 2010). Throughout the past decade, organizations, including the U.S. Department of Education (2004), the National Science Foundation (2002), and the American Association for the Advancement of Science (AAAS; 2008), have stressed the critical importance of increasing the use of technology in the classroom. Teacher demand for digital media – games in particular – is growing rapidly. According to a recent report, games top the list of digital media valued by K-12 teachers across the nation (Grunwald Associates LLC, 2009).

Preliminary game-based research involving students with disabilities indicates that technology-based games (a) can be more effective than traditional instruction (Twyman, & Tindal, 2006); (b) increase motivation (Charlton, Williams, & McLaughlin, 2005); (c) promote self-esteem (Harris & Rea, 2009); (d) provide access to experiences beyond the classroom (Markey, Power, & Booker, 2003); (e) improve skills for extended periods after the game ends (Beaumont & Sofronoff, 2008); and (f) accelerate learning (Charlton et al., 2005).

CONCEPTUALIZING RTI IN 21ST-CENTURY SECONDARY SCIENCE COURSES

Introduction to the Model

In the following, we present a three-tier model that links science video games with principles and features of existing RTI models. Our conceptualization of a hybrid secondary RTI model is designed to (a) emphasize early preventive supports, (b) align curriculum with efficacious instruction, and (c) facilitate progress monitoring and data-based decision making (Fuchs et al., 2010). In designing the model, we attempted to account for criticisms directed at implementation of current RTI models at the secondary level. These include a lack of consideration for new literacies, youth culture, or self-efficacy (Brozo, 2010). We also reflected on Fuchs et al.'s (2010) notion that "it may be necessary to rethink how intervention materials and procedures are fundamentally engineered and packaged ..." (p. 26) and Kavale et al.'s (2008) assertion that "the RTI model cannot deliver the defining feature of special education – individualized instruction" (p. 144). Last, we add our observation of the lack of discussion of universal design for learning (UDL) in current RTI models.

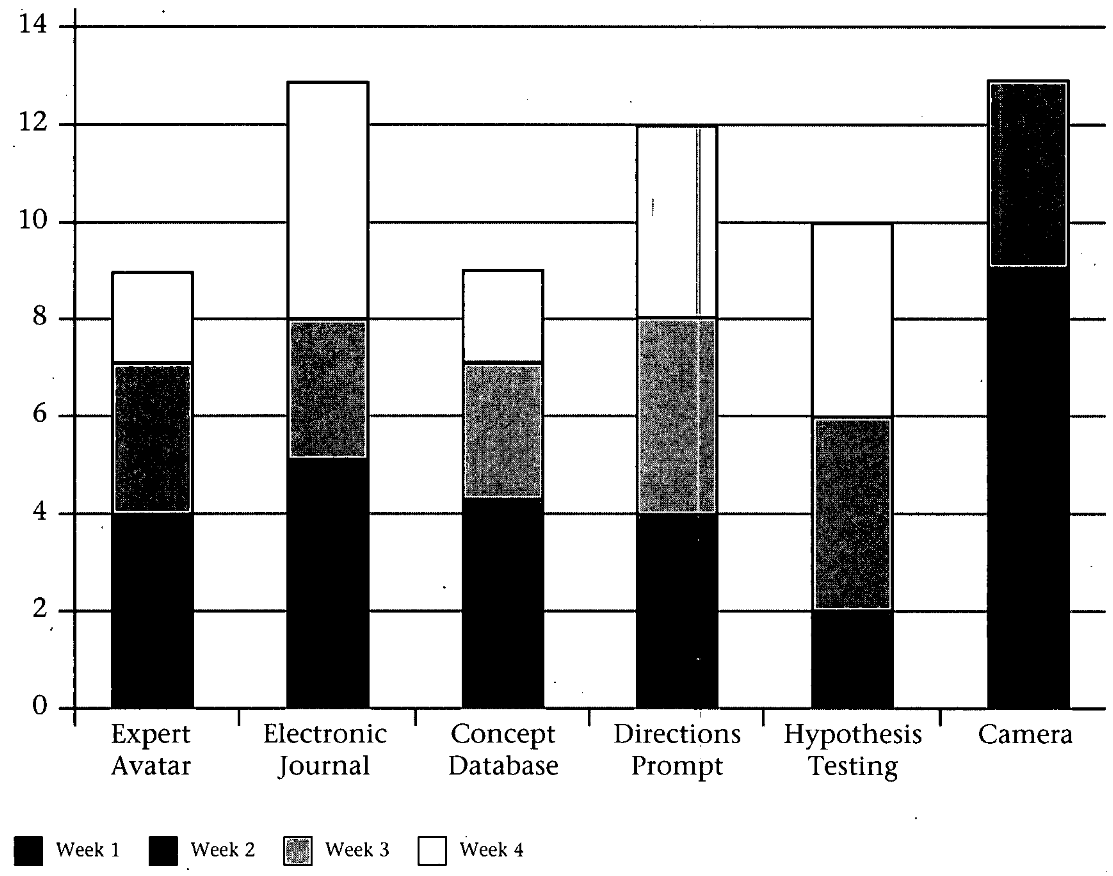
Our model stems from preliminary work on a collaborative Institute for Educational Sciences Innovation and Development grant with Filament Games (http://www.filamentgames.com/projects). The games described here represent the next generation of science video games, which will be available in 2011.

The games in our model are not intended to replace classroom instruction. Instead, they are designed to enhance students' learning outcomes during 30-40 minutes of classroom game play each week. The games are Internet based, which allows students to log in and play them from any computer or handheld device, such as the iPod touch. This presents students with extended opportunities to engage in context-rich scientific inquiry. The games also provide independent practice opportunities and remedial or compensatory instruction that addresses each student's unique needs. We present this model as a work in progress, realizing that adaptations and modifications are inevitable. It is our hope that this model will spur future discussions about the role of technology and UDL in secondary RTI implementation.

How Video Games Support Progress Monitoring

We begin with a discussion on progress monitoring since it is such a critical aspect of RTI implementation. Video games can support progress monitoring through the use of a two-layer interface, which can be conceptualized as a front side or student interface (i.e., the game the student sees and plays) and a backside or management interface (i.e., where all of the data collection occurs). Teachers log into the management interface as administrators. They can create virtual classroom communities by importing class lists from a data management program such as Excel or enter the information manually. Each student is assigned an individual user-

Figure 1. Sample chart demonstrating students' use of UDL-based tools that can be used during progress monitoring.



name and password, which he or she uses to enter and play the game. All students begin the game at the same virtual location. Here they receive a video tutorial from a virtual expert scientist, who describes and models how to play the game. Information in the tutorial includes the goals, tools the students can use, how to navigate in the game, and so on. Students are then prompted to complete a series of challenges that allow them to demonstrate their mastery of the basic features of the game. If the student is unable to complete these challenges, the virtual expert provides immediate corrective feedback, and the student faces a highly similar challenge again.

In the management interface, the teacher sees students' progress in the game in real time. Tools and locations in the student game interface are coded to a corresponding tabular spreadsheet in the management interface so that the teacher has an immediate record of students' actions in the game. For example, if a student forgets the goal for a particular level of the game, he can click on a question mark symbol and receive an oral prompt describing the goal. The teacher would then have a record that the student accessed the tool at that specific time (e.g., 12:53 p.m.). As the game progresses, the teacher has an expanding database of information about how the student navigates within the game.

This information can be used to determine whether the game is being implemented with fidelity or if additional instruction is necessary. The data are also easily exportable and can be charted to show changes in student performance over time. This addresses Vaughn et al.'s (2008) concern that assessments must not be overly burdensome to teachers. It also provides teachers with information to create functional tutoring groups, as advocated by Fuchs et al. (2010). An illustration of this data collection and reporting mechanism is presented in Figure 1.

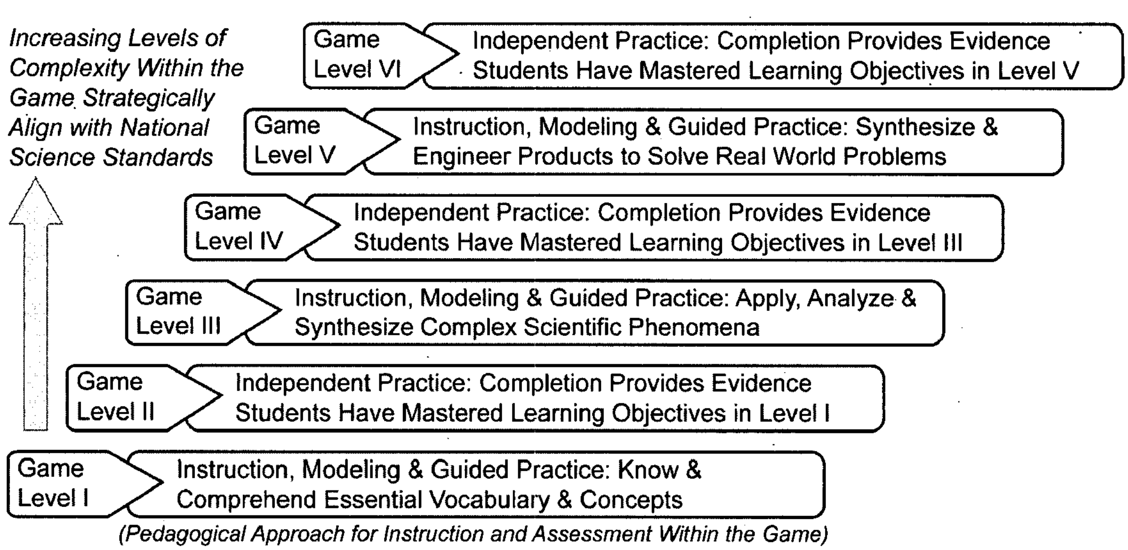
Performance-based assessments during each level of the game are aligned with national science standards. These assessments are designed to provide teachers with accurate information about their students' content knowledge. A distinct advantage to this approach, compared to traditional science assessments that rely on paper-and-pencil tests or lab reports, is that it removes independent variables such as students' reading and writing abilities from the assessment process. (This concept is further articulated in our discussion of the game's relationship to the RTI tiers.) An example of game-level alignment with instruction and national standards is presented in Figure 2.

Additionally, because data can be collected and stored remotely, it can be shared quickly and efficiently with all members of a student's support team using a password-protected website. Large datasets containing this information may be examined using multivariate analyses without any extraneous burden on school personnel. Current large-scale multiplayer games such as *World of Warcraft* are utilizing this functionality. It seems relevant to include the technology in educational contexts.

Tier 1

Tier 1 of the model is implemented in secondary general education science classrooms. Students participate in their general education classroom activities for part of the class, but instead of doing worksheets or other paper-and-pencil content reinforcement activities, they spend 15-20 minutes per class playing a video game that is strategically aligned with the science content standards they are working toward. The game includes design features that are based on the UDL framework (Center for Applied Special Technology, 2009). For example, the game provides scientific data using multiple means of representation (e.g., 3-D animations, tables, simulations). Students are presented with optional ways to demonstrate their comprehension of concepts and phenomena using multiple forms of assessments. The game also allows students to engage with the materials in a diverse manner that fosters motivation and addresses their unique learning needs. Current best practice science research indicates that when game design is combined with UDL, it has the

Figure 2. Relationship among game levels, science standards, and evidence-based instruction.



potential to act as a compensatory scaffold that supports students so that they can access and benefit from science learning activities (Bull & Bell, 2008).

Instruction in the game at tier 1 is also strategically aligned with evidence-based practices. For example, Palincsar, Collins, Marano, and Magnusson (2000) pointed out that students must become fluent with the essential factual and conceptual knowledge before they conduct scientific investigations. To accomplish this, the authors recommend developing specific prompts to guide students through the inquiry process. In the game, an avatar of an expert scientist provides students with background knowledge prior to each new game level. This feature allows critical information to be reiterated for students with processing difficulties at key points during the game. The expert also reiterates the students' accomplishments from the previous game level and explicitly describes their relevance to the next challenge in the game.

McCleery and Tindal (1999) and Kim, Jackson, Yarger, and Boysen (2000) noted that scientific instruction should scaffold students' learning processes by highlighting critical information and helping students develop organizational clarity. To that end, the authors advocate for the use of exemplar models that are combined with explicit instruction. In the game, if a student becomes confused, the expert avatar is available as an icon in the top-left corner of the screen at all times. When the student clicks on the icon, the expert presents information using conversational language, a technique validated by Mayer and Moreno (2002). The avatar models the scientific method, identifying variables and metacognitive processes using a think-aloud model and visual examples to convey a plan to complete the game level challenge.

Mastropieri and Scruggs (2004) added that differentiating instructional materials and use of peer partners during the learning process further facilitated students' knowledge acquisition. Learning in the game is a communal process. Using the management interface, teachers can choose to have students engage in whole-class inquiry, or they can pair students with similar abilities to work collaboratively. Students are then connected and can interact with one another within the three-dimensional game environment. There are multiple pathways for students to choose from. Instruction is differentiated throughout the game by a suite of tools that allows students to individualize their experience based on their specific needs and preferences.

Lynch et al. (2007) added that complex concepts require substantial time to learn, adequate scaffolding, and engaging experiences. Within the game, students are immersed in a virtual world where they use an avatar to participate in environmental studies, research collective problems, and examine events from multiple perspectives. A virtual camera allows students to capture screen images that support or refute their hypotheses. The game environment presents students with technologies that are assistive for some and instructional for others. It provides students with scaffolds to key scientific vocabulary and conceptual knowledge that are unobtainable in traditional print-based environments. Additionally, it connects science to students' interests and outside-school competencies, as advocated by Brozo (2010).

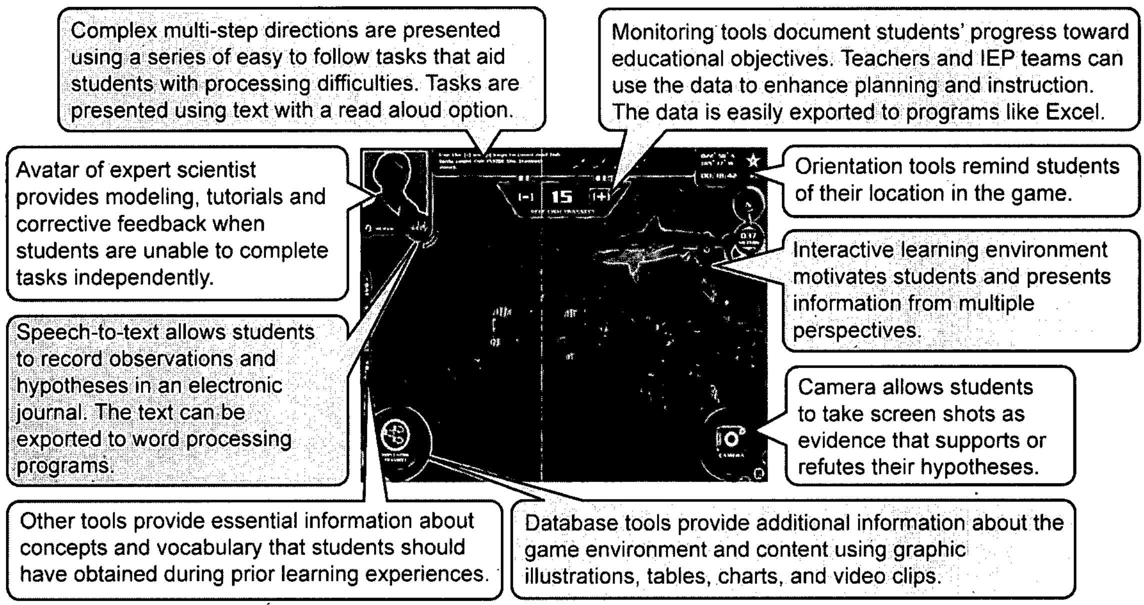
Finally, Swanson (2001), in a meta-analysis of outcomes related to the higher-order processing of adolescents with LD, concluded that three instructional components increased the predictive power of intervention treatments: extended practice, new curriculum, and advanced organizers. Each level of the game builds on previously learned concepts by reiterating critical information and challenging students to apply it with new content. Advanced organizers help students visualize their progress in the game and determine a plan for the next level. Each challenge engages students with novel material, while retaining a consistent palette of scaffolding tools. A screen shot of these supports is presented in Figure 3. Those students who participate in the tier 1 intervention with fidelity and are not successful move to tier 2.

Tier 2

The problem-solving protocol is used to determine when students have met the criteria for moving to a tier 2 intervention. Assessment indicators may include data from the student's game play statistics or performance on paper-and-pencil tests or lab reports. A distinct advantage of including video games as part of the diagnostic process is that it allows team members to pinpoint areas in need of remediation. For example, if a student scores below expectation on exams that involve reading and writing but demonstrates standards-based competencies on the accompanying video game, the team may conclude that the student understands the content but needs a targeted intervention to improve reading comprehension or written expression on the paper-and-pencil exams. In this case, the student could be grouped with students with similar needs and provided with explicit instruction in these areas by the science, special education, or other highly qualified teacher during study hall.

One practice we have observed in classrooms where games are used that we advocate against is having the teacher provide remedial reading and writing instruction to struggling students in place of the game play. This is a tempting option, especially to administrators who may not understand the importance of playing a

Figure 3. Callout boxes illustrate how learning scaffolds in the game incorporate principles from the UDL framework.



video game. We have heard administrators argue that the teacher should provide remedial instruction during class time so that schedules do not have to be altered. However, this approach removes students from the game activity where they have extended opportunities to interact with the content in meaningful ways, possibly reducing their content knowledge on future assessments. Providing remedial support during game play also fails to account for the teacher's integral role in circulating among the students, facilitating conversations about the game content, and assisting students with the game.

For students who are unable to demonstrate standards-based content competency in the game environment but are able to complete paper-and-pencil assessments, standard protocol remedial instruction can be provided within the game. In such a situation, the student's instructional support team can examine the student's game play statistics and determine which tools the student is using and which tools would be most beneficial. They can then limit the student's ability to access nonessential tools, and the student can receive remedial instruction regarding the function and purpose of essential tools in the game. For example, if a student is not making adequate progress in the game, it could be because of a lack of knowledge of the scientific method. The game includes a series of tutorials and activities that provide explicit instruction about the scientific method and then prompt the student to use the method to complete problem-solving activities within the game context. If the student falters, the game recognizes the student's difficulty, provides immediate corrective feedback, and presents the challenge again. This intervention is standardized to ensure treatment fidelity. It also provides real-time data for the instructional support team. And it does not require additional time or resources on the part of the teacher. As with the tier 1 intervention, teachers can group students with similar abilities to further facilitate active student learning. The student can complete the intervention during class when other students are playing the game or during a study hall.

If students are struggling with all aspects (i.e., reading and writing assessments and game play progress), a more intensive tier 2 intervention may be necessary. This may involve remedial instruction using the game during class time and intensive reading and writing support during study hall. The duration of the tier 2 intervention should be flexible. It is possible that game play remediation will take less time than reading and writing. Therefore, the team should utilize all assessment data when determining the time duration of the tier 2 intervention. Students who continue to struggle to meet standards after an extended period of tier 2 intervention move to tier 3.

Tier 3

Tier 3 represents the most intensive level of support for students who do not respond as expected during tier 2 interventions. The instructional support team analyzes data from tiers 1 and 2 and uses the problem-solving protocol to determine additional interventions. At tier 3, it is likely that students will need focused and sustained interventions in reading and writing. While a majority of the RTI research has focused on remediation for elementary students at tier 3, we believe that secondary teams should strongly consider providing students with compensatory assistive technologies. These technologies have been shown to improve the accessibility of learning materials, promote scientific literacy, and improve students' attitudes and self-determination toward participating in future science courses and careers (AccessSTEM, 2008).

Compensatory technologies allow students to access sophisticated content vocabulary across a majority of secondary courses. Examples include reading pens, text-to-speech, and speech-to-text software. Wehmeyer, Agran, and Hughes (2000) noted that high levels of self-determination contribute to a wide array of positive adult outcomes, including job-related skills and achievement. Therefore, fostering the development of self-determination during secondary science classes increases the likelihood that students with LD will successfully transition to careers and/or postsecondary education that focuses on science.

The purpose of tier 3 at the secondary level should be to develop students' problem-solving and self-efficacy skills so that they can successfully transition to meaningful postschool employment or postsecondary education. In addition to compensatory technologies and strategies that support reading, writing, and mathematical computation, instructional support teams should consider explicit instruction in time management, study techniques, and effective communication skills, as indicated by the student's progress monitoring data. Such information should then be incorporated in the student's transition plan. The duration of tier 3 interventions should remain a team decision. We do not view a standard protocol approach as appropriate for the broad range of learners at the secondary level.

Tier 3 interventions in the game environment involve a reduction in the scope of the game with an increased emphasis on UDL-based tools that enable students to follow the scientific method and learn critical content knowledge. For example, within the game, set parameters establish the scope of the three-dimensional interface. Students in tier 1 may have access to six different environments (e.g., urban, rural, undersea, arctic) where they are challenged to solve a complex problem. In tier 2, access may be reduced to three environments, depending on the team's data-based decision. Finally, in tier 3, access may be reduced to one environment, with a sole focus on using the scientific method to understand the concept. The teacher can continuously activate the expert avatar tool so that the student receives ongoing question prompts, modeling, and positive reinforcement. This level of support limits the cognitive load students expend while processing complex information in a three-dimensional problem-solving environment, thereby enabling them to benefit more from the materials presented.

Discussion

An effective secondary RTI model must include tiered interventions that emphasize early preventive supports, aligns curriculum with efficacious instruction, facilitates data-based decision making (Fuchs et al., 2010), and utilizes UDL principles. Table 1 presents an example of how gaming can support RTI principles.

Kirch, Bargerhuff, Cowan, and Wheatly (2007) found that when general education science teachers were able to eliminate curriculum barriers by utilizing diverse instruction, assignment, and assessment strategies, they were overwhelmed by students' abilities to produce meaningful learning outcomes in inclusive settings. The video-game-enhanced RTI model is designed to minimize barriers that inhibit student learning, provide continuous real-time progress monitoring, and elicit positive results such as those Kirch et al. (2007) reported.

The proposed model addresses many of the concerns about RTI implementation at the secondary level noted in the literature. For example, Mastropieri et al. (2006) pointed out that many science teachers do not have the knowledge or dispositions to provide effective instruction for students with disabilities in tier 1 general education classrooms. Similarly, Robinson (2002), in a qualitative study involving high school science teachers, found that the majority of teachers created unified instructional plans that failed to account for the diverse range of students in their classes. Teachers in the study made only limited adaptations or modifications for stu-

Table 1
Relationship Between RTI Principles and Gaming Features

RTI Principles	Gaming Features
1. Early intervention and proactive support	• UDL-based tools provide multiple ways to access learning materials • Expert avatar provides individual feedback • Assistive technologies are included in the game • Motivating 3D environment allows students to extend learning beyond the classroom
2. Evidence-based, individualized instruction, delivered in tiers of increasing intensity	• Diverse evidence-based instructional strategies • Immediate corrective feedback • Options for grouping students in multiple ways • Repeated practice and engagement opportunities • Increased levels of instructional supports at higher tiers • Teachers can limit the scope of the game
3. Systematic progress monitoring and data-based decision making	• Real-time data collection and reporting • Easily exportable format • Data can be shared using password-protected website • Data complement existing paper-and-pencil assessments • Assessments align with national standards

dents with disabilities. The teachers believed that since the learning outcomes for all students are the same, instruction should not be differentiated. Further, Alston et al. (2002) reported comparable results in a study of 323 science teachers, noting that teachers often misunderstood the unique learning needs of students with LD in their classrooms. As a result, they did not make extra efforts to accommodate students with LD or encourage them to pursue careers in the sciences. These types of teacher beliefs pose a clear barrier to effective tier 1 interventions that could be circumvented if differentiation, explicit modeling, and assessment were occurring in the game.

Dymond et al. (2006) reported that the additional time and organization teachers needed to spend on developing science curricular materials based on the UDL theoretical framework was a considerable barrier to their pursuit of this method of instruction. By using the game in concert with existing curricular materials, teachers' time investment in curriculum development is minimized. It should be noted that teachers must dedicate professional development time to learn how to play and manage the game interface. This has proven challenging to some of the less technologically savvy teachers we have worked with. However, those teachers reported that when they participated in professional development that was initiated by their peers, as opposed to the researchers, they were more likely to take an active role in the learning and playing process. Effective video games have built-in tutorials to support teachers' knowledge of game objectives and mechanics so that they can refer back as needed.

Typically, RTI is seen as a linear process wherein students move up and down a ladder of interventions from tier 1 through 3. However, students who were identified with LD in elementary school and who have received years of standard protocol phonics or fluency interventions, for example, without making adequate gains should be treated differently. When problem-solving teams have evidence that effective instruction and interventions are well documented for a particular student, they should consider moving the student directly to the most appropriate tier (Fuchs et al., 2010; Vaughn, Denton, & Fletcher, 2010). In secondary settings where students may have experienced failure, poor self-esteem, and decreased motivation, school teams may not want to lose valuable instructional time with interventions that may be ineffective. Instead, teams should consider moving students who are achieving benchmarks back to tier 1 or tier 2 during semester breaks in the school schedule. This ensures that the student enters the new placement at a natural point in the curriculum and that the tiers do not become a holding place (Barton & Stepanek, 2009). Students can be coached to transfer the strategies that proved successful in higher tiers to the general education curriculum at tier 1.

As Gersten and Dimino (2006) pointed out, research demonstrates that adults are highly unlikely to drastically change their behavior unless they see significant long-term benefit. Adding video games to the RTI model makes teachers' and instructional support teams' jobs easier. Games that are based on UDL principles help teachers support students with diverse instructional needs. Once teachers and teams see the benefit of this approach, we anticipate that they will readily adopt games into the secondary RTI model.

CONCLUSION

In this article we presented a foundational conceptualization of a video game enhanced secondary RTI model. Technology use among individuals with disabilities is increasing at a dramatic rate (Grunwald & Associates LLC, 2009; Lenhart et al., 2003). The educational community has an unprecedented opportunity to harness this powerful instructional and progress monitoring tool as we conceptualize RTI implementation in 21st-century secondary classrooms. Video games can include technology-based scaffolds that augment classroom practices by diversifying instruction and assessment. Highly specialized content can be presented in an engaging three-dimensional environment that is unobtainable using traditional print-based curricular materials. In addition, video games can provide students with assistive and instructional technologies through an easy-to-use interface.

There is a clear need for research with students with LD who participate in game-enhanced curricula at all levels of the RTI model. Specifically, researchers should identify the types of game-based tools that are most efficacious for student learning. A logical first step toward accomplishing this goal is the development of a set of video game design principles that align with UDL. The research and game development community must understand how to create an engaging and motivating video game that is accessible for ALL students, especially students with LD and those who are at risk of learning failure. Future research should also examine the types of tier 2 and tier 3 interventions, group sizes, and length of interventions that are most beneficial to secondary students with LD. This can be accomplished through large-scale studies that strategically analyze intervention protocols and outcomes.

Students with disabilities are at risk for school dropout, underemployment, and a host of other problems associated with lower levels of education. However, with the help of school professionals who are dedicated to improving instruction under the RTI framework, and the powerful technology now available to support this effort, the outcome for students with disabilities may be much improved.

REFERENCES

AccessSTEM. (2008). *The Alliance for Access to Science, Technology, Engineering, and Mathematics.* Retrieved September 20, 2008, from http://www.washington.edu/doit/Stem/disability_type.html

Alston, R. J., Bell, T. J., & Hampton, J. L. (2002). Learning disability and career entry into the sciences: A critical factor analysis of attitudinal factors. *Journal of Career Development, 28,* 263-275.

American Association for the Advancement of Science. (2008). *Benchmarks for science literacy.* Retrieved December 15, 2009, from http://www.project2061.org/publications/bsl/online/index.php

Barnes, A. C., & Harlacher, J. E. (2008). Clearing the confusion: Response-to-intervention as a set of principles. *Education and Treatment of Children, 31*(3), 417-431.

Barton, R., & Stepanek, J. (2009). Three tiers to success. *Principal Leadership, 9*(8), 16-20.

Beaumont, R., & Sofronoff, K. (2008). A multi-component social skills intervention for children with Asperger Syndrome: The junior detective training program. *Journal of Child Psychology and Psychiatry, 49*(7), 743-753.

Berkeley, S., Bender, W. N., Peaster, L. G., & Saunders, L. (2009). Implementation of response to intervention. *Journal of Learning Disabilities, 42*(1), 85-95.

Brozo, W. G. (2010). Response to intervention or responsive instruction? Challenges and possibilities of response to intervention for adolescent literacy. *Journal of Adolescent and Adult Literacy, 53*(4), 277-281.

Bull, G., & Bell, R. L. (2008). Education technology in the science classroom. In R. L. Bell, J. Gess-Newsome, & J. Luft (Eds.), *Technology in the secondary science classroom* (pp. 1-8). Arlington, VA: NSTA Press.

Cawley, J., Hayden, S., Cade, E., & Baker-Kroczynski, S. (2002). Including students with disabilities into the general education science classroom. *Exceptional Children, 68,* 423-435.

Center for Applied Special Technology. (2009). *UDL guidelines 1.0.* Retrieved June 20, 2009, from http://www.cast.org/publications/index.html

Charlton, B., Williams, R. L., & McLaughlin, T. F. (2005). Educational games: A technique to accelerate the acquisition of reading skills of children with learning disabilities. *The International Journal of Special Education, 20*(2). Retrieved June 20, 2009, from http://www.internationaljournalofspecialeducation.com/

Dalton, B., Morocco, C., Tivnan, T., & Mead, P. (1997). Supported inquiry science: Teaching for conceptual change in urban and suburban classrooms. *Journal of Learning Disabilities, 30,* 670-684.

Dymond, S. K., Renzaglia, A., Rosenstein, A., Chun, E. J., Banks, R. A., Niswander, V., et al. (2006). Using a participatory action research approach to create a universally designed inclusive high school science course: A case study. *Research & Practice for Persons with Severe Disabilities, 31,* 293-308.

Fuchs, L., Fuchs, D., & Compton, D. (2010). Rethinking response to intervention at middle and high school. *School Psychology Review, 39*(1), 22-28.

Fuchs, D., Fuchs, L., & Stecker, P. (2010). The "blurring" of special education in a new continuum of general education placements and services. *Exceptional Children, 76*(3), 301-323.

Gersten, R., & Dimino, J. (2006). RTI (response to intervention): Rethinking special education for students with reading difficulties (yet again). *Reading Research Quarterly, 41*(1), 99-108.

Grunwald and Associates LLC. (2009). *Digitally inclined.* Retrieved March 10, 2010, from http://www.pbs.org/teachers/_files/pdf/annual-pbs-survey-report.pdf

Harris, A. L., & Rea, A. (2009). Web 2.0 and virtual world technologies: A growing impact on IS Education. *Journal of Information Systems Education, 20*(2), 137-144.

Ikeda, M. J., Grimes, J., Tilly III, W. D., Allison, R., Kurns, S., & Stumme, J. (2002). Implementing an intervention-based approach to service delivery: A case example. In M. R. Shin, H. M. Walker, & G. Stoner (Eds.), *Interventions for academic and behavior problems II: Preventive and remedial approaches* (pp. 53-69). Bethesda, MD: National Association of School Psychologists.

Jacobson, M. J., & Archodidou, A. (2000). The design of hypermedia tools for learning: Fostering conceptual change and transfer for complex knowledge. *The Journal of the Learning Sciences, 9,* 145-199.

Kavale, K. A., Kauffman, J. M., Bachmeier, R. J., & LeFever, G. B. (2008). Response to intervention: Separating the rhetoric of self-congratulation from the reality of specific learning disability identification. *Learning Disability Quarterly, 31*(3), 135-150.

Kim, T., Jackson, D F., Yarger, D. N., & Boysen, P. J. (2000). Principles for the design and use of simulations in science learning as exemplified by a prototype microworld. *Journal of Computers in Mathematics and Science Teaching, 19*(3), 237-252.

Kirch, S. A., Bargerhuff, M. E., Cowan, H., & Wheatly, M. (2007). Reflections of educators in pursuit of inclusive science classrooms. *Journal of Science Teacher Education, 18,* 663-692.

Lee, M., & Erdogan, I. (2007). The effect of science-technology-society teaching on students' attitudes toward science and certain aspects of creativity. *International Journal of Science Education, 11,* 1315-1327.

Lenhart, A., Horrigan, J., Rainie, L., Allen, K., Boyce, A., & Madden, M. (2003). *The ever-shifting Internet population: A new look at Internet access and the digital divide.* Washington, DC: Pew Internet and American Life Project. Retrieved September 10, 2008, from http://www.pewinternet.org/pdfs/PIP_Shifting_Net_Pop_Report.pdf

Liu, M, & Bera, S. (2005). An analysis of cognitive tool use patterns in a hypermedia learning environment. *Educational Technology Research and Development, 53,* 5-21.

Lynch, S., Taymans, J., Watson, A. W., Ochsendorf, R. J., Pyke, C., & Szesze, M. J. (2007). Effectiveness of a highly rated science curriculum unit for students with disabilities in general education classrooms. *Exceptional Children, 73,* 202-223.

Marino, M. T. (2009). Understanding how adolescents with reading difficulties utilize technology-base tools. *Exceptionality, 17,* 88-102.

Marino, M. T. (2010). Defining a technology research agenda for elementary and secondary students with learning and other high-incidence disabilities in inclusive science classrooms. *Journal of Special Education Technology, 25*(1), 1-28.

Markey, C., Power, D., & Booker, G. (2003). Using structured games to teach early fraction concepts to students who are deaf or hard of hearing. *American Annals of the Deaf, 148*(3), 251-258.

Mastropieri, M. A., & Scruggs, T. E. (2004). Science and schooling for students with LD: A discussion of the symposium. *Journal of Learning Disabilities, 37,* 270-276.

Mastropieri, M. A., & Scruggs, T. E. (2005). Feasibility and consequences of response to intervention: Examining the issues and scientific evidence as a model for the identification of individuals with learning disabilities. *Journal of Learning Disabilities, 38*(6), 525-531.

Mastropieri, M. A., Scruggs, T. E., Norland, J. J., Berkely, S., McDuffie, K., Tornquist, E. H., et al. (2006). Differentiated curriculum enhancement in inclusive middle school science: Effects on classroom and high-stakes tests. *The Journal of Special Education, 40,* 130-137.

Mayer, R. E., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review, 14,* 87-99.

McCleery, J. A., & Tindal, G. A. (1999). Teaching the scientific method to at-risk students and students with learning disabilities through concept anchoring and explicit instruction. *Remedial and Special Education, 20,* 7-18.

Moriarty M. A. (2007). Inclusive pedagogy: Teaching methodologies to reach diverse learners in science instruction. *Equity and Excellence in Education, 40,* 252-265.

National Assessment of Educational Progress. (2007). *The nation's report card; science.* Retrieved April 1, 2010, from http://nces.ed.gov/nationsreportcard/naepdata/report.aspx

National Science Foundation. (2002). *Women, minorities, and persons with disabilities in science and engineering.* Arlington, VA: Author.

Palincsar, A. S., Collins, K. M., Marano, N. L., & Magnusson, S. J. (2000). Investigating the engagement and learning of students with learning disabilities in guided inquiry science teaching. *Language, Speech, and Hearing Services in Schools, 31,* 240-251.

Reschley, D. J. (2005). Learning disabilities identification: Primary intervention, secondary intervention, and then what? *Journal of Learning Disabilities, 38,* 510-515.

Robinson, S. (2002). Teaching high school students with learning and emotional disabilities in inclusion science classrooms: A case study of four teachers' beliefs and practices. *Journal of Science Teacher Education, 13,* 13-26.

Swanson, L. H. (2001). Research on interventions for adolescents with learning disabilities: A meta-analysis of outcomes related to higher-order processing. *The Elementary School Journal, 101,* 331-378.

Twyman, T., & Tindal, G. (2006). Using a computer-adapted, conceptually based history text to increase comprehension and problem-solving skills of students with disabilities. *Journal of Special Education Technology, 21*(2), 5-16.

U.S. Department of Education. (2004). *Toward a new golden age in American education: How the Internet, the law, and today's students are revolutionizing expectations. National Education Technology Plan 2004.* Retrieved February 2, 2007, from http://www. ed.gov/about/offices/list/os/technology/plan/2004/index.html

U.S. Department of Education. (2010). *Transforming American education: Learning powered by technology.* Retrieved May 2, 2010, from http://www.ed.gov/technology/netp-2010

Vaughn, S., Cirino, P., Wanzek, J., Wexler, J., Fletcher, J., Denton, C., et al. (2010). Response to intervention for middle school students with reading difficulties: Effects of a primary and secondary intervention. *School Psychology Review, 39*(1), 3-21.

Vaughn, S., Denton, C. A., & Fletcher, J. M. (2010). Why intensive interventions are necessary for students with severe reading difficulties. *Psychology in the Schools, 47*(5), 432-444.

Vaughn, S., Fletcher, J. M., Francis, D. J., Denton, C. A., Wanzek, J., Wexler, J., et al. (2008). Response to intervention with older students with reading difficulties. *Learning and Individual Differences, 18*(3), 338-345.

Vaughn, S., Wanzek, J., Woodruff, A. L., & Linan-Thompson, S. (2007). Prevention and early identification of students with reading difficulties. In D. Haager, J. Klingner, & S. Vaughn (Eds.), *Evidence-based reading practices for response to intervention* (pp. 11-27). Baltimore: Paul H. Brookes Publishing Co.

Wehmeyer, M. L., Agran, M., & Hughes, C. (2000). A national survey of teachers' promotion of self-determination and student-directed learning. *The Journal of Special Education, 34,* 58-68.

Werts, M. G., Lambert, M., & Carpenter, E. (2009). What special education directors say about RTI. *Learning Disability Quarterly, 32*(3), 245-254.

White, B. Y., & Frederiksen, J. R. (1998). Inquiry, modeling, and metacognition: Making science accessible to all students. *Cognition and Instruction, 16,* 3-118.

Please address correspondence concerning this article to: Matthew T. Marino, Washington State University, P.O. Box 642132, Cleveland Hall, Pullman, WA 99164-2132; e-mail: matthewmarino@wsu.edu