AC 2007-3110: COLLABORATIVE, MULTI-DISCIPLINARY LEARNING THROUGH DYNAMIC, VIDEO GAME KNOWLEDGE MODULES: SYSTEM ENGINEERING APPLICATION

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Collaborative, Multi-disciplinary Learning Through Dynamic, Video Game Knowledge Modules: System Engineering Application

Abstract: By implementing student teams and incorporating a systems engineering approach, we have developed a unique video game-based product that combines the entertaining aspects of a popular video game set in a magical world, with dynamic, adaptable, multi-disciplinary instructional material. The video game knowledge module (VGKM) system integrates the fun NeverWinter Nights™ role-playing video game environment with educational knowledge modules, an entertaining story line, and out-of-game activities to build and demonstrate a compelling, interactive, collaborative, multi-disciplinary learning tool. Different knowledge modules can be built by interested faculty, educators, or entrepreneurial development teams, emphasizing different subject matter and integrated to produce a tailored course of study, correct academic deficiencies, or assist with training and certification, qualification, or assessment programs. Knowledge modules can span disciplines, departments, and even colleges and universities. A built-in assessment and rewards and punishment capability is included in the VGKM. The knowledge modules have a variety of dynamic features such as multiple or single user capable, directed in-game interaction by an educator, remote site multi-user interaction over the internet, localized WLAN/LAN networks, and asynchronous learning. A significant aspect of VGKM is character persistence. This allows the student to transfer a character from module to module, and game to game while maintaining the characters attributes, “possessions”, experience, accumulated items, abilities, and in-game treasures. Finally, incorporating out-of-game experiences and seamlessly integrating them into the in-game environment is a unique aspect of our VGKM.
1.0 Introduction

Learn by playing! Many of the more entertaining video games that are of interest to younger and older audiences—such as the phenomenally popular World of Warcraft from Blizzard Entertainment or NeverWinter Nights (NWN) from Bioware—are often seen as a time-wasting activity from an educational or perhaps even a societal point of view. Even so, Blizzard’s World of Warcraft currently has over 7 million enthusiastic on-line subscribers that spend countless hours—sometimes years—in this entertaining virtual experience.

As part of playing the video game, these “gamers” assimilate all sorts of facts, methods, and techniques to competitively advance their virtual characters in the game. What if the in-game experience actually had an educational and learning component to it while, at the same time, preserving the entertainment aspects of the game—basically advancing your character by learning something real, valuable, and educationally relevant?

We have taken the NeverWinter Nights video gaming environment with its “world-building” capability to develop and demonstrate an entertaining, interactive, knowledge module for collaborative, multi-disciplinary learning. The knowledge modules integrate in-game learning experiences, an entertaining story line that is consistent with the precepts of the game, and out-of-game activities such as running external engineering models, conducting research, analysis, or interaction/collaboration with other students, faculty or even commercial partners.

These knowledge modules can be generated for any topic—business, math, science, engineering, or humanities for example—for students of all ages. Different knowledge modules can readily be built by interested faculty, educators, or entrepreneurs emphasizing different subject matter and integrated to produce a tailored course of study, correct academic deficiencies or used in a training and certification program. Knowledge modules can span disciplines, departments, colleges and universities, and can cross industrial, government, and international boundaries.

As an example, we have used a requirement driven, systems engineering approach to spirally develop this project. The initial educational content included an introduction to systems engineering, optics, and human factors. A built in assessment and rewards capability has been included in the knowledge module(s) as well as a means to link modules that are generated by different collaborators. Platform issues such as multiple or single users, directed in-game interaction by an educator, remote site multi-user interaction over the internet, and asynchronous learning are also addressed.

In keeping with the systems engineering basis, the roots of this video game knowledge module, we will be outlining our project using a system engineering approach. The discussion will start by briefly describing the stakeholders’ requirements and goals, followed by the concept of operations. The stakeholder requirements and concept of operations are used to derive the system level requirements along with technical performance measures and a qualification strategy. Next the feasibility studies, functional analysis, and design and prototype development sections detail key development aspects of our VGKM. Then, a risk assessment, reliability, maintainability, and availability analyses look at the project risks and maintenance aspects of our project, respectively. We conclude with a marketing analysis of the VGKM.
2.0 Stakeholder Requirements

The exciting concept of Video Gaming Knowledge Modules (VGKM) is geared towards educators, students, colleges, quite possibly, anyone who has educational or training motivations. Our stakeholders are educators and academicians, VGKM enablers such as academic administrators, financiers and investors, information technology (IT) folks, VGKM developers and maintainers, business personnel such as contracting, intellectual property, marketing, entrepreneurs and of course the VGKM users. We used a Quality Functional Deployment (QFD) approach to capture our stakeholder’s requirements. A concept of operations was then developed based on the stakeholder requirements to provide a scope and focus for the VGKM development.

3.0 Concept of Operations

The Concept of Operations (CONOPS) for VGKM describes operational aspects of our project. Based on the stakeholder requirements, the CONOPS provides a focus for the development effort and is useful in setting the scope for the project. Figure 1 shows the VGKM CONOPS.

The CONOPS shows key features of our VGKM such as development of an interesting, independent story line shown by the book in the central part of Figure 1. Also shown is the required capability of in-game rewards and punishments and a link to the external game environment for external quests such as library assignments, interaction with professors or individuals of note, or modeling and simulation activities. Results of these external activities are brought back into the game and are part of the requirements for in-game character advancement. The VGKM are tailored to different subject matter and come with their own assessment and/or certification module. Figure 1 also shows that the VGKM can be run in stand-alone, LAN/WLAN, in a classroom, or over the internet allowing for local or remote learning modes. The CONOPS shows the instructor developing or modifying the VGKMs. This certainly is possible; however, opportunities also exist for entrepreneurs to develop VGKM educational content. Ultimately,
entrepreneurial development of educational and storyline content may be more cost effective since a small business can focus its resources and specialize for optimal development.

4.0 System Requirements, Technical Performance Metrics, and Qualification Strategy

The stakeholder requirements and CONOPS were used to derive the system level requirements. Subsequently, the system level requirements were used to develop key performance parameters and ultimately drive the design of the VGKM. Technical performance measures were developed for the system requirements along with a qualification strategy. By implementing the QFD technique for the VGKM system we found that the following system capabilities were the most critical to the success of our development effort: 1) the ability to use the existing Neverwinter Nights Aurora toolset and the NeverWinter Nights game as a development platform, 2) the ability to accurately identify and capture subject matter essential elements of information, 3) the ability to develop interesting in-game encounters to motivate the student, 4) providing a reward and punishment system, 5) development of an independent story line that can be used to progress characters through the VGKM, 6) the ability to have in-game, real-time instructor interaction with the student, 7) the ability to modify and adapt the VGKM for content updates, 8) the ability to save play status and port characters between different VGKMs, and 9) the ability to seamlessly incorporate out of game activities in the in-game story line. We then conducted
feasibility studies to determine whether or not we could satisfy the system requirements and provide the essential system capabilities just discussed.

5.0 Feasibility Studies

Feasibility studies were conducted to analyze the system requirements to determine whether or not each requirement could be satisfied and also if the critical system capabilities identified in the preceding section could be successfully implemented. The feasibility studies focused predominantly on our technical ability to satisfy the system requirements. To supplement the feasibility studies, a risk assessment and marketing analysis were also accomplished and the results are discussed later in this paper. Some high-lights of the feasibility studies are discussed below.

Content Creation

The NeverWinter Nights game platform was chosen because of its interesting game play and its unique world-building toolset (Aurora toolset). The Aurora toolset allows VGKM developers to quickly and easily create new landscapes, storylines, and educational content. Producing customized modules within the NWN environment is a well documented capability of the NWN game which enables the developer to build tailored “encounters” with personalized conversations to teach or assess any topic desired. The subject matter is currently limited by scripted language with mathematical topics included through the external game environment.

Character save and data portability

The ability to save and access individual progress is an important element in the learning system; fortunately, this is an inherent feature in the NWN game. A player selects their character and all information about this character is saved in the player’s profile and character status sheet. In addition, the quests that the player has completed, or is in the progress of completing, are stored in the in-game journal. Character persistence is necessary for students to venture from one learning environment to another. This will enable them to study different educational material in different VGKMs. Character persistence can be accomplished through player profiles, which are currently a feature of NWN. They are used to allow gamers to play in online games with other players from around the country and the world. Players log in to an online portal and then they can access games with their saved character’s status, including game progress, accomplishments, and abilities.

Real-time in-game interaction

One requirement of the VGKM is the capability for real-time web-based play with instructor interaction. The instructor can participate either as another character with the same account privileges, abilities, and limitations as the students or the instructor can participate through the dungeon master (DM) client with expanded abilities. For the later case, the instructor can interact with anyone in the game, initiate encounters at will, control in game characters, instantly move to any place within the game, create and destroy items or creatures, use any of the abilities
in the game, and many other expanded features. In order to use the expanded DM features, the instructor must host the game.

Hosting

At the early stages of the project, two basic alternatives have been considered for hosting a network based game. The first option is to locally host a game on an Individual’s Personal Computer (IPC). The second option is hosting on the Bioware Server (BS). Initially, the VGKM is created in the Aurora toolset and is saved in a file with a .mod extension. This file can be transferred from one computer to another via FTP, e-mail, or copied to a media device, assuming that the recipient of the .mod files already has NWN loaded on their computer. Intellectual property issues must be taken into account when sending the VGKM in a non-secure environment since any of the material in the .mod file is readily accessible by anyone with the NeverWinter Nights game. One major advantage for posting to the BS is that no one can download the VGKM from the BS but anyone with the right password can play it from anywhere in the world with internet access. Another hosting option is to use academic IP assets for hosting the VGKM. This is essentially no different from the IPC option.

We used the Analytical Hierarchy Process (AHP\(^7\)) to evaluate which hosting option would initially be the best approach. The AHP is a useful tool developed by Saaty to comparatively rank multiple alternatives against an arbitrary set of criteria. Some nice features of the AHP are that 1) the AHP accommodates the use of qualitative evaluation criteria, and 2) the AHP provides a measure of the consistency of your decision making process. Five factors were used in determining which hosting option to pursue. These factors were:

- Stability – the stability of a particular platform in reference to preventing crashes
- Ease of Use – the degree of effort required to operate and maintain the VGKM
- Security – the degree of security offered by each platform
- Cost – cost of labor and fees to initiate and maintain the VGKM platform option
- Longevity – how long into the future the platform will be available to users

Figure 2 shows the results of the AHP. The upper table in Figure 2 shows the relative comparison between the BS and IPC options with the various evaluation criteria. For example,
in terms of stability, the IPC option will perform less favorably compared to the Bioware server by a factor of 1:5 because the individual’s PC is only as stable as its hardware and there may not be IT support. The Bioware server is professionally maintained and is supported by an experienced IT/maintenance staff. More importantly, the BS server maintenance is for now included as part of the NWN gaming experience and there is no monthly subscription fee.

**In-game hooks**

Another requirement is that the knowledge modules have “hooks” or enticements for players to learn new subjects other than the subject they initially embarked to learn. For example, a player who has been learning Systems Engineering principles throughout the game may have an encounter with a game character and be offered the opportunity to learn about physics if the individual desires. If the individual is interested, the game character could either instruct the individual in the topic or direct the individual to where he/she may learn these other subjects. In-game encounters can be written to direct students to a variety of multi-disciplinary topics. The underlying story lines must also be consistent with this idea and convey to the characters that they should learn more about other subjects.

**Coordinated classroom participation**

Coordinated classroom participation within the game is feasible. A class or class teams may login to the same game over a Local Area Network (LAN) and play a synchronous game in real time. The instructor may also choose to participate as either a DM or a player. This will be accomplished the same way as synchronous play over the internet except it will be restricted to the LAN and not over the Internet.

**Data Security**

User character profiles, game progress, experience, skills, assessment, and certification data must be protected. The NWN game environment provides built in password security for both local computer and server created characters. No additional security is needed to protect the user’s personal data. Bioware sells stand alone premium NWN modules solely through a digital distribution method that also allows community members to become published authors. Module distribution, security, and protection by independent authors are built into the Aurora Toolset for module creation. Copyright protection would be required to protect developers story/character development and also for education material such as instructor topics and certification materials.

**6.0 Functional Analysis**

After conducting the feasibility analyses, we performed a functional analysis to break our development into manageable functional components based on the system requirements. We broke our system into the functional blocks shown in Figure 3. Functional Block Diagrams (FBD) and Functional Flow Diagrams (FFD) were used to expand the details of each of the
functional blocks shown in Figure 3. As an example, we show the Functional Flow Diagram for the assessment module in Figure 4. In the assessment module, the student is quizzed based on completing a certain amount of the subject matter material in the VGKM. The storyline advances the character and sends the character to an assessment module after completing a set number of learning experiences that are controlled by in-game quest givers. At the completion of the assessment, the in-game proctor can award items based on the results of the assessment. For example, upon completing an assessment and missing 7 points out of 100, the proctor could award 93 small gems to the individual. The individual then places the gems in a secure container that only the character and instructor can access, and the instructor can get the results of the assessment at their convenience by looking into the characters secure container.

All of the system level requirements were allocated into the functional block structure as illustrated in Figure 3. FBDs and FFDs were used to expand each of the functional blocks and requirements, technical performance measures, and satisfaction arguments were derived for the lower levels. The system level requirements were captured in an A-specification (System Specification) whereas the lower level requirements are documented in B-specifications (Product Specifications) and D-specifications (Process Specifications). The Dynamic Object Oriented Requirements System (DOORS) from Telelogic™ was used to capture all the requirements, their attributes, their satisfaction arguments, and their relationships to each other and to the qualification strategy. Once completed, the set of requirements were used to design the VGKM and subsequently build a prototype as discussed in the next section.

7.0 Design and prototype development

The system documentation developed thus far was used to design and build a prototype VGKM. The intent was to develop this product in an orderly fashion using student teams over many semesters. The system engineering approach was adopted to facilitate the transition
between student teams, establish a requirement driven product baseline, and a spiral evolution process complete with exit criteria for each spiral. The resulting VGKM prototype was developed to mitigate risk and to demonstrate that all of the requirements could be satisfied. It is not intended to be a complete, commercially viable, stand-alone product but instead demonstrate the technical feasibility of the VGKM. We now discuss some of the critical details of the VGKM design and prototype development effort.

The story line of the VGKM is crucial to the game itself. Without a story line that engages the individual player, the game becomes boring and the player quits playing. Each player begins the game in the Inn of the Golden Dragon within the city of Aydoril. The player discovers that in order to understand more about the situation of the story they must first visit the Federation of Intellect and Truth in the northern part of the city. Players are looking for lost pages of an ancient book of knowledge. As gamers meet characters within the story, the characters ask them to answer certain questions related to a particular educational topic (systems engineering for instance). Successfully answering these questions allows the individual to progress through the game. Some characters in the game give the individual a bit of information or directions about a...
topic in order to teach a subject. Other characters direct the students to other topics of interest. Woven around the learning is a seamless, exciting, quest-based plot that captures the interest of the student, motivates the student to continue playing and learning, and rewards the student for successes, and punishes them for mistakes (e.g. damage or temporary death to their in-game characters or character party, loss of items, or treasure, loss of experience, or bad performance on an in-game assessment). If done right, the actual learning “seems” almost incidental amongst the heady rush of battle against the minions of the enemy, acquiring rare magical items and treasures, confounding the enemy and questing with friends.

The design of the storyline has been left uncomplicated at this time to allow more freedom in the future to develop the story. However, we have found that a comprehensive storyline framework is necessary to cohesively integrate plot development between various student teams. An interesting collaborative idea is to develop the storyline architecture and then use English students in creative writing assignments to develop the plot. Computer science, electrical engineering, or systems engineering students or entrepreneurial VGKM developers could implement the storyline along with instructional content using the Aurora toolset and the NWN platform.

Currently, the VGKM prototype teaches players selected Systems Engineering topics and allows them to learn a few other topics (ex. History, Mathematics, Human Factors, and Optics). Figure 5 shows the design diagram for the system engineering topic. The instructor’s learning topics are converted using the NWN Aurora toolset into a character dialog or in-game item such as a book or a scroll. The VGKM player learns the subject matter topic through conversations with VGKM game characters. A critical component of these in-game conversations is that the student can be directed to activities outside of the game such as library assignments, externally running simulations, conducting analyses, interacting with faculty, professionals, or other students—basically any learning activity. The storyline is developed to accommodate and integrate these activities.

The completed VGKM prototype module can be loaded by the instructor using the NWN game DM client and posted to the internet, run over a LAN or WLAN, or run in a stand alone mode. Player access can be controlled by an instructor assigned password. Certification record/status, out-of-game activities record/status, knowledge topic record/status, and quest record/status can be saved in the user’s character journal. Figure 6 shows a screen shot of our assessment submodule for our current VGKM prototype. Assessment results and number of attempts can be saved in the user’s character inventory or in secure in-game containers in the form of items. The user’s character sheet can store the character attributes such as level, skill and experience.

The ability of the instructor to interact with his or her students inside the NWN environment is a crucial tool in the assessment of student progress throughout the VGKM. The professor can join students in the knowledge modules in one of two ways:

The first option is to participate by playing the role of Dungeon Master; this requires the DM client which comes standard with the NeverWinter Nights software bundle. Another way instructors can interact with students in the game is to join the game as a regular player. This uses the same multiplayer technology that allows a class to play together or students to play
across the globe. By joining the game this way, the instructor has all the abilities of a normal player and can interact with his/her students in real-time. The professor can help students or assess knowledge. However, there is one drawback to this type of in-game interaction. By joining the game as a regular player, the professor’s in-game character is susceptible to all the

![Knowledge Module Design Diagram](image)

Figure 5: Knowledge Module Design Diagram

challenges of the game (i.e. the instructor’s character can still be killed and has to tackle obstacles in the same way as normal characters). Depending on the VGKM, this may or may not be of significance to the professor, but it is one major difference to take into account when deciding on how to interact with students.

8.0 Risk Assessment

A risk assessment was accomplished to identify areas of potential risk to the VGKM project. Each requirement associated with the VGKM carries an associated risk. This section discusses the identified risks connected with a representative set of customer requirements along with possible risk mitigation approaches that may be undertaken to minimize the risk.

*Obsolescence:*
One risk (low) is NWN becoming obsolete and unavailable with the release of NWN2. The VGKM built in the original NWN Aurora toolset is incompatible with NWN 2, so any person with NWN 2.0 or later will not be able to play the VGKM. The risk is that Bioware will eventually not support the original NWN game and that all content developed in the original NWN format will be lost or unusable. Approaches to mitigate this risk include collaborating with Bioware to keep NWN available for academic purposes or investigate patches to VGKM or NWN2 to make them compatible. Another option is to work under Bioware’s strategic development plan for the NWN game and upgrade content to new formats as they become available.

**Resources:**

Another risk (low to medium) is the availability of resources to produce a marketable product in a timely fashion. Our current approach uses student teams which is sufficient for educational purposes, but may be risky from a time-to-market point of view. Approaches to mitigate this risk are to seek grants for further development, collaborate with interested parties, form teaming relationships and partnerships, and work with investors and entrepreneurs to obtain additional resources.
**Content Development:**

Not every educator wants to tackle the overhead of learning the Aurora toolset to translate their educational content into the NWN compatible format. This risk (high) could prevent interested faculty from trying the VGKM approach because of the perception that it is too difficult to successfully implement their material using the Aurora toolset. Approaches to mitigate this risk include intellectual property and financial incentives such as module-based residual income for content developers; seminars and workshops on the use of the Aurora toolset with supporting demonstrations; on-line education, tutorials, and Aurora toolset examples; the use of graduate students to implement content; creative teaming arrangements between the English department (creative writing) and computer engineering, electrical engineering, and/or systems engineering departments (implementers); and entrepreneurial activities such as small-businesses that develop content with an instructors input. As a final note, the Aurora toolset developed by Bioware is an extremely powerful and easy to use product. It is a unique feature that serves as an enabler for the creation of dynamic educational content in the framework of a highly successful magical world.

**Assessments:**

The issue of traditional supervised assessment presents some challenges similar to other on-line testing approaches. For instance how do we know for sure that the student being assessed at a remote location is in fact the right student, does not have outside assistance, and basically does not cheat? For on-line versions of the VGKM, the traditional testing center approach would work where a student must show ID to a remote proctor and take the in-game VGKM assessment in a controlled environment. The proctor could hand out an access code that allows the student entry to the in-game assessment chamber and could even enforce timing constraints. For that matter, the VGKM could enforce timing constraints and can implement separate versions of the same test. Other options separate from the testing center approach could be to treat the in-game assessment as preparation for a traditional in-class assessment or to intentionally design the assessment for group participation. The later approach works well for courses that use team projects such as engineering management, business, and some humanities.

Other risks investigated include server availability, storyline viability, and the efficacy of the DM client. For brevity’s sake we defer comments except to note that no significant insurmountable challenges exist and mitigation approaches have been identified.

**9.0 Reliability, Maintainability, and Availability Analyses**

Reliability, maintainability, and availability analyses were conducted based on the resources required to implement the VGKM\(^3\). We assumed a server based implementation such as what would be seen at an academic institution with IT support or at a business that would be set up to implement the VGKM. This removes the instructor from having to deal with maintenance and IT issues and integrates the VGKM with the academic institution or business IT infrastructure. We looked at the required IT components such as server hardware, network hardware, peripheral hardware, power hardware, software, and chassis. The summary of our analyses is shown in Figure 7.
The goal of the VGKM system was to provide maximum availability and limited down time. This is not currently an explicit system requirement, but sound design using available Commercial-off-the-Shelf (COTS) hardware with built-in redundancy provides a reliable systems approach to implementing the VGKM. The use of redundant power supplies, standalone UPS, hot-swappable hard drives with parallel processing, and a sound preventive maintenance schedule will offer the users of the system many years of service with minimal down-time and interruptions. Based on currently available hardware, the total system Operational Availability is over 90% as shown in Figure 7.

10.0 Market Analysis

The purpose of this marketing analysis is to look at the entrepreneurial and business aspects of the VGKM. The market strategy of VGKM is to enter the business arena as a market challenger. We intend to adopt our own strategies in order to challenge the market leader’s position. Our market objective is to provide the consumer with an innovative and motivational learning tool, customizing a knowledge quest to suit the gamers’ learning style and discipline, while allowing the instructor and student to thoroughly evaluate their progress at the students’ pace. To understand the market environment, we conducted a Strength, Weakness, Opportunity, and Threat (SWOT) analysis. What makes SWOT particularly powerful is that, with a little thought, it can help uncover hidden opportunities. Also, by understanding the weaknesses and threats of our product, decisive action can be taken to compensate or eliminate the weaknesses and counteract the threats.

The strengths of the VGKM lie in the uniqueness of the learning approach. It is the first educational video game product designed for general purpose education (math, sciences, engineering, and humanities) and professional development (certifications, qualifications, and professional education) that provides an entertaining, multi-disciplinary, collaborative, dynamic, interactive, and adaptable learning environment and seamlessly integrates real-world activities. As far as we know, the NWN Aurora toolset is the only readily available commercial product that is sufficiently sophisticated to accomplish this task. Out-of-game activities are incorporated

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<th><strong>VGKM System Maintainability &amp; Availability</strong></th>
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<tr>
<td>$A_i$ Inherent Availability</td>
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Figure 7: VGKM System Level Maintainability and Availability
to build and demonstrate an entertaining, interactive, knowledge module. Different knowledge modules can be built by interested faculty or educators emphasizing different subject matter and integrated to produce a tailored course of study, correct academic deficiencies, or assist with training and certification/assessment programs. The learning curve associated with the NWN Aurora Toolset is relatively low, so someone unfamiliar with the NWN software could learn how to navigate and build worlds easily. The independent storyline captures the students' interest and paves the way for learning. Lastly, the VGKM has the capability to network over the internet, which enables classroom learning, teamwork, and facilitates instructor interaction.

Weaknesses of the VGKM are that customizing a knowledge module must be done by the interested faculty or educator. This could be seen as a setback, since the knowledge module must be created by someone who is familiar with the software and the associated requirements for the VGKM as well as the subject matter. It may be difficult to convince potential customers that their specific discipline can be taught or learned in this kind of environment. The knowledge module creator must possess a certain level of computer skills in order to operate the software. Finally, with many knowledge modules being created, there is a potential risk of the storyline becoming conflicting, which could turn off the user’s interest.

The opportunities for the VGKM include implementing content in the new NWN2 format. The better graphics and capabilities of NWN2 coupled with our VGKM would be very attractive to buyers. Simulated gaming environments are becoming an increasingly popular trend and many industries are implementing and looking for new ideas at conferences. Simulation, Education, and Training Conventions would be a great place to network with potential investors and implementing the VGKM using the internet can provide a world-wide customer base.

Finally, the threats involved in our business venture are convincing the simulation world that our product is effective. There is currently a new version of the NWN software, NWN2, which has recently come out; competitors could use this as a platform for their ideas. Funding is always a threat at the beginning stages of a product. Competitors could take our unique VGKM, tweak it slightly and call it their own. There is at least one known existing system based on a similar premise—the University of Minnesota has implemented a NWN project for teaching journalism. In their implementation, they have changed the traditional NWN landscape into a suburban town.

As a new entrant to the market, the VGKM could potentially face obstacles due to capital requirements and face resistance from organizations that have related projects such as the NWN journalism project at the University of Minnesota. Bioware, being our only supplier simplifies the determination of the suppliers. At this time, there are no commercially available alternatives to the NWN Aurora toolset—the main enabler for our approach. As a result, the supplier’s power is quite high. Fortunately, Bioware is relatively flexible with their product and expects their consumers to use their Aurora toolset to implement their own ideas. With regards to the power of the buyer, the VGKM must be priced to convey the quality and performance of the game, but it has to be affordable for students and educators. Since an interactive video gaming learning environment appeals to such a broad audience, the buyer volume and concentration will be a key factor in the buyer’s bargaining power. Finally, the internet is a driving force in bargaining power. Since, the internet plays a significant role in the VGKM we are open to a
large customer base, while being able to target our desired market sector. At this point in time, the interactive learning module is moving beyond its embryonic stage and is transitioning between the innovators and early adoption phase of the Technology Adoption Cycle. With the right team and resources, the technology is poised for a competitive advantage.

Product position in the market is an important consideration for our buyers. It defines who we want to reach and where our product will compete. Figure 8 shows the expected position of the VGKM in the market with regards to product differentiation and relative price.

![Figure 8: Product Positioning in Market for VGKM](image)

Since the VGKM system is a unique concept, this places our product at a high relative differentiation in comparison to other products currently available in the market. The majority of the development cost is in the content development team since the development platform already exists and shipping and distribution costs are expected to be comparatively low. The overall cost distributed amongst all the units of the product to be sold would bring the company to a low relative price range as shown in Figure 8.

11.0 Conclusions

We have presented a systems engineering approach to developing a unique video game based learning environment through video game knowledge modules. Our approach harnesses the entertaining aspects of a popular magical video game—NeverWinter Nights—and implements an adaptable educational framework to teach multi-disciplinary topics. We used student teams and a systems engineering approach to develop a requirements driven project that demonstrates the technical feasibility of the VGKM. In order to develop the VGKM, stakeholder requirements were determined and translated into system level requirements. A functional analysis was accomplished to define the VGKM system’s functional blocks and system requirements were allocated and derived for each of the identified functional blocks. The design and build process yielded a prototype that demonstrated the feasibility of the VGKM. Risk analyses were performed to identify project risks and risk mitigation steps were implemented. Reliability,
maintainability, and availability analysis were conducted to estimate key maintenance related
technical parameters and the operational availability was determined to be 90% for commonly
available equipment. Finally, a marketing analysis was conducted to address entrepreneurial and
business aspects of the project. This analysis showed that our VGKM system is well poised in
the technology adoption cycle and, given adequate resources, the VGKM has excellent product
positioning in the market. The VGKMs are applicable to academic institutions, professional
development programs, distance learning, certification and qualification programs, and K-12
outreach programs.

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