

“Can I wait go to the hospital until after Math class?”

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Abstract: *How can a math game initiate such a powerful change in perspective that students no longer choose to opt out of being attentive in math class?* Florida Virtual School asked the same question in July of 2011 and partnered with Imagine Education to find the answers. Using funds secured from the Next Generation Learning Challenge, FLVS and IE expanded and refined the existing story-based adventure game, *Ko's Journey*, and embarked on an ambitious pilot test in both the virtual and traditional 7th grade math classrooms. This revealing presentation will cover the basis of curriculum design and game integration as well as the results of attitudinal and performance data collected in during the eight-month pilot.

Overview

A true story from Rio Gallinas, a public middle school, in rural New Mexico...

“A student broke his arm on the playground – I don't mean a small break – it was a compound fracture. It was just kind of hanging there, so we had him call his parents to meet him at the hospital and he got on the phone...I was standing there, and he said, “Can you wait to go there at 10AM... after math class?”
- Sean McLean, 7th Grade Math Teacher, one day after his students' first experience with an Imagine Education math game.

Florida Virtual School has partnered with Imagine Education, creators of *Ko's Journey*, to pilot the use of story-based adventure gaming in middle math classes. The transformation in a student's response to math class from "I hate math" to "Math class ROCKS" can happen almost immediately during engaging gameplay if it is implemented at just the right time and in right way. The quantified results reflecting this change—seen in four consecutive years of data collected on low-income minority students who showed an 80% gain in proficiency on state tests—are eclipsed only by a few thousand repeated requests echoed in a popular refrain of student enthusiasm, “Do we get to play the game today?” (Laidlaw, 2011)

Imagine Education (IE) is founded on the idea that through story, one of the of the oldest, most powerful architectures of human learning, educational games have the power to transform student attitudes, improve test scores and establish a foundation for future learning. *Ko's Journey*, IE's first national on-line game release comes directly from the classroom. The concept behind the game was created by Dr. Scott Laidlaw, co-founder of IE and a teacher determined to engage students whose chances of succeeding in math were dismally low, not just because of a lack of prior knowledge, but because of the negative emotion they held for the subject. IE games are a revolution in learning, crafting every math problem so that it makes sense conceptually, and holds relevance, within the game mechanic and story.

The concept that math must make sense within the context of the game is a drastic departure from the majority of educational math computer games available, where an equation or exercise has been dropped into a traditional video game context. The add-on approach might encourage students to complete math drills—but it reinforces the lack of meaning and relevance math has in the mind of a student, particularly for students who are struggling with real-life challenges. It is not by accident that each and every pixel of *Ko's Journey* is unique. The story itself is of a human right of passage, not of monsters; the student takes on the role of a young girl in ancient wilderness, not a robotic avatar; and the math within the game invariably, absolutely, and always is transparent, not puzzling or hiding within the guise of an unrelated action.

Pilot Model

Florida Virtual School and Imagine Education embarked on a challenging pilot project in the fall of 2011 to test the efficacy of *Ko's Journey* in the virtual school setting. FLVS integrated the game into the current M/J Math 2 course, typically taken by 7th grade students, by building an introduction module that preceded the normal course content. This is a diversion from previous in-course testing

of *Ko's Journey* where students were directed to go in and out of the game at various points throughout the course. The logic behind this design was to build a foundation for the core skills needed throughout the 7th grade course. Game play would be continuous for the first three weeks and then subsequent instruction in the course modules would reinforce concepts learned. FLVS worked with Imagine Education and John B. Cooney, Ph.D. of the University of Colorado, to conduct a comprehensive quantitative, and qualitative, research and assessment. Students were randomly assigned to both an experimental and control classroom for the FLVS six teachers involved in the study. Students were surveyed on interest level, technical skills, and math proficiency before the starting the game as well as a post-attitudinal survey after finishing the game module. A comparative pre-test and post-test were administered in the game platform to analyze learning gains. Results of this study are still being tabulated and are expected to be available in June of 2012. It is also important to note that while the FLVS pilot was underway, Imagine Education was conducting a parallel study in 20 classrooms in 10 traditional schools across the country using similar study criteria. FLVS is expecting to see increased student engagement, motivation, and performance from the students who began the course with the *Ko's Journey* module.

Project Description

The roots of *Ko's Journey* lie in a public middle school in rural New Mexico, where less than one-third of the classroom was proficient in math, and games where math made sense within a context-rich story resulted in immediate improvements. Bolstered by an initial climb in test scores when compared with peers beginning at the same level, the popularity of the games led them to become the primary component of the math curriculum. Studies evaluating the effectiveness of the in-classroom game showed impressive results; on comparing the New Mexico state average score (Standards Based Assessment in Mathematics, 5th-8th Grades) to the scores of students involved in IE's games (public schools) show a clear difference. The data are validated in that both groups of students began at the state average of approximately 28% level of proficiency. IE students involved in the games for two or more years showed a rate of proficiency more than double that of their New Mexico peers (n=91) (Laidlaw, 2011).

After a year of beta-testing a hybrid model between the large board game format and web-based software, IE began production of a fully web-based model of the most stable and engaging game architecture tested in the classroom and beta released this first-of-its-kind game in April 2010.

Technical Features, User Experience & Common Core State Standards

By presenting math within a rich and meaningful story context, we find that students of all abilities are able to stop asking "Why Math?" and start thinking *about* math, while engaging in repetitive, context-rich practice. *Ko's Journey* is a unique, first-of-its-kind attempt to use the newest pedagogy of video game technology as something more than animated flashcards or repetitive practice. Dr. Keith Devlin, author, Stanford Mathematician and leading researcher into educational math game technology, has recognized of *Ko's Journey* as an outstanding example of a "second generation math game" in recent presentations—taking us in the direction we must be headed if we are to capitalize on the true gains in learning that are theoretically possible with video game pedagogy, as outlined in his recent work (2011, 2012).

The central aspect of *Ko's Journey*, as a learning module, is a story-based game. Delivered via any common web browser through a blend of Ruby on Rails, Flex SDK and Adobe Flash, it is functional in over 90% of test cases on extant computers and netbooks used in schools throughout the US. Using an architecture called a "string of pearls" design, the game is played on individual machines. Students begin by logging onto their personal dashboard to take a multiple-choice pre-test and open-ended survey, which are saved and sent to the teacher dashboard. Next, students delve into the game through an introductory movie (as the game downloads behind the scene) that immerses students in the story of Ko, a young girl in ancient wilderness who must make her way back to her kin and a math module that teaches about the origin and use of degrees in a circle. Their first task is to set a compass to the proper degree and enter the correct number of steps Ko must take to "find" the next "clue."

Once "Ko", or rather the student role-playing her, "finds" the guidebook, the concept of the game truly begins. It is here that the heart of *Ko's Journey* is found, in an elegant game mechanic that allows students to progress using math in a highly functional and repetitive approach targeting critical areas of the Common Core State Standards (CCSS) for 7th grade math, and reiterates associated

background knowledge including the critical areas in 5th and 6th grade mathematics. Using continuously dynamic factors, students progress through the game and experience *Ko's Journey* by adding how much "they" are carrying in "stones", see how fast they can travel using a graph in the guidebook, determine their "biome velocity", multiply that speed by the number of "phases" they have left in the day, and then apply distance to scale. It starts with simple whole numbers and no adjustment for the biome then, as the student progresses, the challenge increases. Toward the end of the game, a student must add fractions with non-common denominators, read and comprehend a graph, take a percentage of a number, multiply that decimal by unique factors, and then apply that number to scale, all to make a single movement of Ko. The imbedded practice and assessment found throughout the game architecture is powerful. It is nearly impossible to not understand the basic concepts presented then put them into functional use.

As an endorsing partner of the CCSS initiative, IE created *Ko's Journey* to provide students with a focused, immersion-based learning experience for the following 7th grade math CCSS: (1) developing understanding of and applying proportional relationships; (2) developing understanding of operations with rational numbers and working with expressions and linear equations; and (3) solving problems involving scale drawings and informal geometric constructions, and working with two- and three-dimensional shapes to solve problems involving area, surface area, and volume. *Ko's Journey* also incorporates and reinforces CCSS for 5th and 6th grade math, including fractions; division using two-digit divisors; concepts of ratios and rates; and using expressions and equations. Throughout the course of the game, students encounter deep-learning concepts of critical thinking, collaboration and learning-to-learn. The numerous complexities within the game architecture provide opportunities for students to discuss and learn from one another about how to approach various problems, while limiting copying from one another or sharing simple answers.

In the game mechanic, there is one key feature that makes it all work, and creates the deep learning experience that really affects change for the students. Math is coherent in how it might be applied. This game mechanic is not just an add-on—it came from an actual 100-mile trek through the highest, most remote mountains in the Peruvian Andes, where a similar type of math was applied during climbing. The difference may seem subtle, but it is the key difference between a short-lived jump and long-term student growth. It is a believable mechanic for students because the game architecture is repetitive, simple, increasingly more difficult, and the math concepts are deeply learned with a growing emotional confidence. And because they make sense, the math concepts anchor.

The technical features for progress are intentionally simple. If the student enters an incorrect answer, they do not progress, but receive encouraging feedback to "try again", at which point they can re-enter the guidebook to review how to solve the problem. Teachers have reported that even students who are scoring well below their grade level on math assessments are still able to navigate, enjoy and learn from the game. Within the string of pearls design, as Ko travels, students encounter additional story-based modules that make sense within both the scope of the overall game and from an applied mathematical perspective. For example, early in the game, Ko must save a sick wolf pup by mixing medicines in specific ratios. Later along, she finds the North Star using Cartesian Coordinate mapping and a line equation. And, because she does find the North Star, she is able to travel at night, allowing for more travel time and distance to be gained, a major reward for students.

Learning Improvement & Program Enhancement

There is something else crucial to the architecture and concepts underlying *Ko's Journey* – it is not only what the students experience, but also what they do not. There are no arbitrary rewards such as points and awards. In our research, IE found that a point-based reward approach in math games encourages students to attempt to get done more quickly just to get the points, which leads to more mistakes and a lowered conceptual learning. A powerful finding of IE is that students (with the exception of summative assessments) work with more purpose when math is carefully embedded in a story. A teacher who recently used *Ko's Journey* in her Math Enhancement class was pleased to note that "Activities were repeated and scaffolded in complexity to drill the concepts, but in an interesting way through the student's engagement in the story, not rote memorization."

Stories, in narrative structures, provide a way to capture the complexity, specificity, and interconnectedness of an experience and conjoin them into coherent, meaningful, unified themes (Olson, 1990). Social scientists such as Bruner (1985) spoke of a narrative mode of thought and Sarbin (1986), who proposed story as a "root metaphor" for the study of human conduct, supported

an interpretive method that embraces the use of narrative. They contend that “story” provides a unit of meaning that stores and permits retrieval of the experience. Story provides an incredibly powerful means for learning, helping us store information in our memory for referral. In other words, *compelling story pedagogy takes learning deeper*.

With nearly a decade of experience of imbedding math and other textbook concepts within games, IE knows that skill at solving contextually-rich math does not always easily transfer over to skills in solving problems on a math test. Research has shown that math that is learned in any one context does not automatically transfer well to any other. Lave tested this with clothing tailors who were using a type of math, but could not then conduct the math in a textbook form. The reverse was also true; students who had mastered the math in textbook form could not apply it to the tailoring situation (Lave, 1988).

Thus, a critically important—and unique—feature of *Ko’s Journey* is a set of learning modules that first reference math concepts in the game, then reference the same concepts in a different but engaging context, and then finally provide practice of the concepts in a standardized test context. The technical architecture to support transfer of learning in *Ko’s Journey* also provides the basis for the imbedded student progress tracking. After students complete a module in the game on the Flash side (i.e.: the compass task), a “transfer of learning” lesson and quiz is triggered behind the scenes to be completed, and results are posted on the student and teacher dashboards.

Curriculum Specialists worked with educators and teams of college students (including minorities for modeling purposes) in a challenge format, to create additional engaging contexts for the same math concepts already seen in the game through dynamic videos that explicitly teach transfer of learning along with standardized assessments. In the enhanced Bridge Curriculum, students watch the videos via the student dashboard, take sample quizzes, and can use animated tutorials to improve their understanding of concepts. Through our existing architecture, scores and data are automatically sent to the teacher dashboard, along with formative, deep-thinking narrative responses completed by students. Another feature to be added is animation of the existing problem set images found in the game guidebook.

Assessment Model

There are six primary features that assess student learning in *Ko’s Journey*, creating a comprehensive overview of math proficiency, including: (1) progress in the game itself; (2) interactive problems sets; (3), a deep-thinking narrative response to video; (4) a pre-and-post multiple choice measure that will be developed as part of our research to assess students in CCSS; (5) multiple choice, short answer and narrative questions related to “bridge content;” and (6) a unique, pre-select format to enhance mathematical language. All features are fully integrated into the web-based game and provide automatic tracking for teachers.

The first aspect of assessment (in-game) is the most simple, and the most powerful: if a student answers a problem incorrectly, they do not progress. This is usually avoided by nearly all web-based curricula, for in the eyes of many developers, this architecture has a fatal flaw: “What if the student gets stuck?... They could be there forever.” As the goal is to create an autonomous process of learning, getting stuck means the end of the game, especially with the complex problem sets seen in a program like *Ko’s Journey*. However, for *Ko’s Journey*, this concept works. Because student engagement is higher, student effort to continue is higher. This small slice of cause and effect means that this type of assessment actually drives competency. During beta-tests, extremely low proficiency students (in the lowest 10% of their grade levels) continued playing *Ko’s Journey* and searched for solutions during recess breaks or lunch periods. If students did get “stuck”, they looked to the in-game guidebook to seek answers, and were successful in nearly all cases. Within *Ko’s Journey*, getting stuck provides an opportunity for deeper learning, as a student searches for answers and learns-to-learn. Like all aspects of *Ko’s Journey*, assessment of game progress is functional in that mechanics are conceptually accurate. For example, when a student sets the compass to the incorrect angle, instant feedback is provided as Ko then walks at the incorrect angle.

Goal

IE seeks to circumvent emotional resistance to math by providing students with an opportunity to create a relationship to math that is based on purpose and meaning. By introducing CCSS and exercises in a manner that makes sense within an engaging and complex story, students’ attitude –

and aptitude – in math is transformed. When the story-based learning is fully integrated into the classroom curriculum, teachers can then monitor their students' successes within the game and build upon this in the classroom to create a lasting impact.

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