Wii® MATH FOR THE MIDDLE SCHOOL

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Technology should be seen as essential tools for learning and doing mathematics in the middle school classroom. Computers, calculators, and other technologies permits students to reason mathematically and solve problems in ways that are more efficient that without these tools. Students can explore mathematical topics through enhanced representations, and the ranges of problems are often extended when using technologies to present the school mathematics (Van de Walle, Karp, Bay-Williams, 2010). NCTM (2000) states, "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning," (p. 24).

Classroom technologies are often limited to the thought of as calculators, computers and infinite internet resources. Although students not only have these technologies at home, they also own video gaming systems, and handheld products such as smartphones, tablets, and portable gaming devices. Middle school students are major consumers of video gaming devices, especially Nintendo Wii. The purpose of this paper is to explore how to incorporate a popular gaming device, which students often associate with positive fun experiences, to teach middle school mathematics.

Why Wii?

Nintendo Wii is popular, fun, and affordable. Nintendo Entertainment System was an instant hit in 1985, selling over 60 million units and in 1989 Nintendo's Game Boy sold over 150 million systems worldwide (Nintendo, 2012). Throughout the 90s and early 2000s Nintendo released other popular gaming systems such as Super Nintendo Entertainment System, Nintendo 64, Game Boy Pocket, Game Boy Advance, GameCube, Game Boy Advance SP, Nintendo DS, and Nintendo DS Lite. Finally, in 2006 the ever so popular Wii introduced the revolutionary features of wireless motion-sensitive remote controllers, built-in Wi-Fi capability, along with a host of other features which made Wii the best-selling latest generation console system in the world (Nintendo, 2012).

An instant curiosity and desire to play Wii by many was due to the wireless controllers that allow players to stand and model the movement of the Mii (or player's character) within the game; instead of using your thumbs to select buttons on standard wire-based controllers. The game Wii Sports is most often sold with the Wii console. Therefore, players can physically mimic the actions of hitting a baseball, tennis ball, golf ball, or throwing a bowling ball down an alley. Games can provide intrinsic motivation as a part of the learning environment. The learning context and internal motivation are central to educational success, particularly in learning mathematics (NCTM, 2000; Ma, Xin,

Kashor, & Nand, 1997; Sedig, 2008). Research supports the belief that games and the "act of play" have positive effects on student motivation and retention of knowledge more than conventional lecture-based instruction.

Many school districts offer teachers the opportunity to apply for $300 - $500 technology grants. For less than $500, teachers can purchase the gaming console, four controllers, wireless sensor, a controller charging station, and a carrying case for easy storage or to transport between classrooms if sharing the device among multiple teachers.

Wii Sports and Mathematics

Wii Sports is the game packaged with the Wii console, and consists of various types of games and training sessions for baseball, tennis, bowling, golf, and boxing. Naturally, all sports encompass a plethora of mathematics ranging from basic computations of averages, percent, and ratios to number theory, statistics, algebra, and calculus concepts.

The intent of using games within Wii Sports to enhance teaching mathematics is twofold: 1) to show students mathematics is encompassed within their world as a child or young adult, and 2) learning and doing mathematics can be fun and physically interactive (not just paper-and-pencil computations). However, as a hard-working teacher, how does one find time to create student-centered, problem-based lessons around Wii? Completing a search on Google, NCTM Illuminations, or other popular educational sites is a typical first step to search for lessons that incorporate Wii games. Unfortunately, these searches reveal some websites with only one or two brief lesson ideas, which lack classroom management techniques, worksheets, and assessments. In 2011 the book, *Investigating Middle School Mathematics: Classroom Lessons Using Wii Sports* by Christina Gawlik, provided educators with six classroom ready lessons, student worksheets, multiple-choice assessment questions, classroom management suggestions, interdisciplinary integration options, graphing calculator investigations, opportunities for field trips, and family involvement for homework. Herein, an overview of the first mathematics lessons will be discussed from the above mentioned book.

Math Lessons with Wii Sports

Lesson 1 – The Baseball Investigation

The training session called Home Run Derby will be used with five students who will be bat for 10 consecutive balls. Students will collect data such as: type of ball hit, distance and speed of each ball. Analysis of data will include finding the sum of each type of ball hit, with their respective fractional representation that will be converted in to decimal and percent forms. Next, students will transfer this data into a circle graph.

Before students collect data the teacher can begin a class discussion with the following questions:

- Who has played baseball or softball on a team? With friends or family? At school? Or recreationally?
- What are some key components about the game?
- What is a foul ball? Base hit? Home run? Strike?
- What types of data could be collected during a baseball game?

After five students have played one game of Home Run Derby, and students have analyzed the data collected, provide follow-up discussion questions:

- What was interesting about the data?
- How do you think the data would differ if you played the same game with a real bat and ball?
- What might the circle graph look like if we incorporated the data from more students?

Allow five different students to play the Home Run Derby game, and create a circle graph just with their data, and another circle graph with all ten students' data. Students should discuss similarities and differences among the three circle graphs and provide theories for why the graphs turned out as they did. Figure 1 below depicts a sample recording worksheet, where Figure 2 displays the data analysis worksheet and circle graph to be created by students.

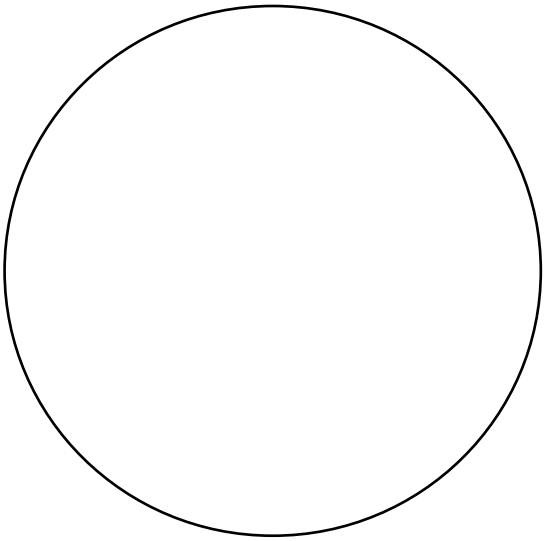
Figure 1 – Home Run Derby Recording Worksheet

Player 1:

	Foul Ball	Base Hit	Home Run	Strike	Speed
Ball 1					
Ball 2					
Ball 3					
Ball 4					
Ball 5					
Ball 6					
Ball 7					
Ball 8					
Ball 9					
Ball 10					
Totals					

Figure 2 – Home Run Derby Data Analysis and Circle Graph

	Total Number of Each Hit	Fraction	Decimal	Percent	Degrees of Circle
Foul Balls					
Base Hits					
Home Runs					
Strikes					



Students' mathematical investigation does not end after comparing circle graphs. Next, students will determine the average ball speed and range per person, and whole group; then determine what type of graph would be best to depict this data. Later, students will use a graphing calculator to create a scatterplot for the distances of each ball from three players. A set of multiple choice assessment questions follow this lesson. The questions are designed in the context of this lesson, where data is presented in a tally chart from five children who played the Home Run Derby. Students have to identify the correct bar graph that pairs with the tally chart. Moreover, students have to read a scatter plot, calculate percent, determine probability, and find the mean of the given set of base hit data.

These multiple choice assessment questions mimic mathematical content found on middle school high stakes tests. However, the questions are posed in the context of the Home Run Derby lesson; which may provide a deeper meaning behind the mathematics over a standard mathematics question for example, find the mean of the numbers 7, 3, 5, which has no context associated with the numbers. This type of problem is often referred

to as a *naked problem*. The assessment questions found in *Investigating Middle School Mathematics: Classroom Lessons Using Wii Sports* (Gawlik, 2011), are contextual with the Wii Sports games.

Pilot Lesson Results

Lessons from Christina Gawlik's (2011) book, *Investigating Middle School Mathematics: Classroom Lessons Using Wii Sports*, were piloted within two 7th grade mathematics classes in a middle school located in north Texas in April and May of 2011. The first pilot class consisted of seven students enrolled in a mathematics laboratory class, designed to assist students in rebuilding their foundational mathematics skills. The second pilot class had 22 students on grade-level enrolled in the 7th grade mathematics course.

Students in both classes were eager to collect data after initial directions were presented for Lesson 1 – Home Run Derby Investigation. When one student was up-to-bat, the remaining classmates were divided into three groups. Group 1 was responsible for collecting the distance of each ball hit. Group 2 recorded the type of ball hit (foul, base hit, home run, or strike), and Group 3 documented the speed of each ball. All students were observed to be supportive and encouraging to each player at-bat, by their remarks of, "Great hit," "Yay," or "Next ball, you can do it!" Clapping or tapping of the pencil on the desk was a routine established by the teacher earlier on in the year when students showed praise to each other for a job well done. Additionally, both sets of students were able to determine the fractional representation of each type of hit, and simplify fractions if possible. The first pilot class relied on the use of the calculator for converting their fractions to percents, whereas the second pilot class had a number of students who either completed the calculations by hand or used a calculator.

Students in both classes struggled when posed with the task of creating a circle graph that represents the data collected. In particular, students could not determine the number of degrees in a circle for each of the four categories of types of ball (foul, base hit, home run, or strike). After some prompting from the teacher about proportional reasoning, students in both classes quickly started to write a proportion to solve (see Figures 3 and 4 for student samples). It was apparent through observations, that solving proportions was a concept recently covered in both classes, as students approached this task from a purely computational point of view. For example, one student from Class 2 whose work is shown in Figure 3 needed to determine 12.5% of 360 degrees. They were unable to connect 12.5% is half of 25%, and 25% was 90 degrees of a circle. After a brief one-on-one conversation with that student, they were able to describe that 50% of the circle would be 180 degrees, and then determine that 10% of 360 degrees was 36 degrees, which represented the number of base hits in their data. This student was not confident in their verbal mathematical reasoning even after praise and confirmation from the researcher, and reverted to solving a proportion to support their reasoning (see proportion on right side of Figure 3).

Figure 3 – Student Sample from Class 2

***Wii™* Activity Sheet #1—Home Run Derby (continued)**

Consider all players' statistics and complete the table below. Show your work.

- Record the number of total foul balls, base hits, home runs, and strikes from the students who played the game.
- Determine the fraction representation of the data, convert the fraction to a decimal, and represent the number as a percent.
- Determine the number of degrees for each category to create a circle graph.

	Total Number of Each Hit	Fraction	Decimal	Percent	Degrees of Circle
Foul Balls	5	$\frac{5}{40} = \frac{1}{8}$	0.125	12.5%	45°
Base Hits	4	$\frac{4}{40} = \frac{1}{10}$	0.1	10%	36°
Home Runs	22	$\frac{22}{40} = \frac{11}{20}$	0.55	55%	198°
Strikes	9	$\frac{9}{40}$	0.225	22.5%	81°

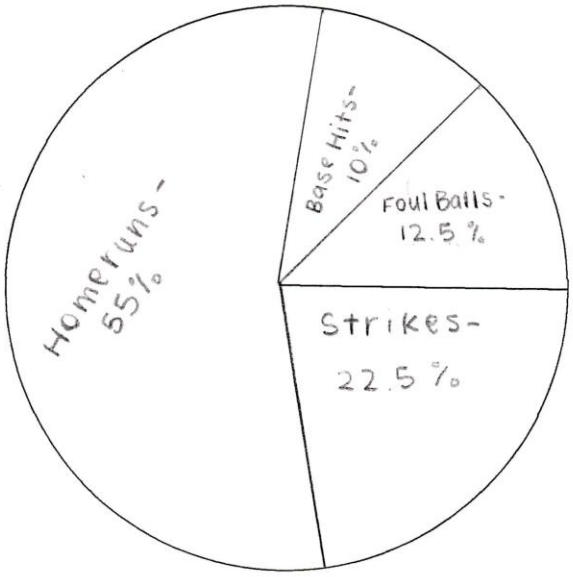


Figure 4 – Student Sample from Class 1

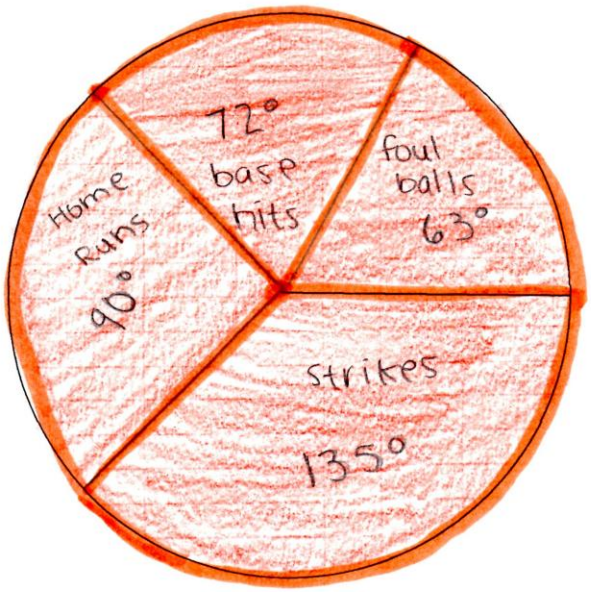
Wii™ Activity Sheet #1—Home Run Derby (continued)

Consider all players' statistics and complete the table below. Show your work.

- Record the number of total foul balls, base hits, home runs, and strikes from the students who played the game.
- Determine the fraction representation of the data, convert the fraction to a decimal, and represent the number as a percent.
- Determine the number of degrees for each category to create a circle graph.

	Total Number of Each Hit	Fraction	Decimal	Percent	Degrees of Circle
Foul Balls	7	$\frac{7}{40}$	0.175	$17\frac{1}{2}\%$	63°
Base Hits	8	$\frac{7}{40} = \frac{1}{5}$	0.20	20%	72°
Home Runs	10	$\frac{10}{40} = \frac{1}{4}$	0.25	25%	90°
Strikes	15	$\frac{15}{40} = \frac{3}{8}$	0.375	$37\frac{1}{2}\%$	135°

$\frac{x}{360} = \frac{17.5}{100}$ $\frac{x}{360} = \frac{20}{100}$ $\frac{x}{360} = \frac{25}{100}$ $\frac{x}{360} = \frac{37.5}{100}$



At the end of the piloted lessons students, were informally asked to describe their thoughts about using Nintendo Wii in the classroom. Common themes were identified as:

- It was fun to use games found at home in our math class
- They [students] can work together and individually [throughout the lessons]
- Those with Wii games at home, want to repeat the investigations with their family and see how it [their data] compares with the class data
- They [students] could impact the data collected and wanted to repeat experiments to identify changes in the graphs (and analyses)

Wii Investigations Supports Constructivism

Constructivism theory of learning has an adaptive function; the effect of social interaction, language, and culture on learning is developmental and constructive. Fosnot (2005) described general principles of learning derived from constructivism as:

- Learning is not the result of development; learning *is* development. It requires invention and self-organization on the part of the learner. Thus, teachers need to allow learners to raise their own questions, generate their own hypotheses and models as possibilities, test them out for viability, and defend and discuss them in communities of discourse and practice.
- Disequilibrium facilitates learning. "Errors" need to be perceived as a result of learners' conceptions, and therefore not minimized or avoided. Challenging, open-ended investigations in realistic, meaningful contexts need to be offered which allow learners to explore and generate many possibilities, both affirming and contradictory. Contradictions, in particular, need to be illuminated, explored, and discussed.
- Reflective abstraction is the driving force of learning. As meaning makers, humans seek to organize and generalize across experiences in a representational form. Allowing reflection time through journal writing, representation in multisymbolic form, and/or discussing connections across experiences or strategies may facilitate reflective abstraction
- Dialogue within a community engenders further thinking. The classroom needs to be seen as a "community of discourse engaged in activity, reflection, and conversation" (Fosnot, 1989). The learners (rather than the teacher) are responsible for defending, proving, justifying, and communicating their ideas to the classroom community. Ideas are accepted as truth only insofar as they make sense to the community and thus they rise to the level of "taken-as-shared." (Fosnot, 2005, pp. 33-34)

Students can experience the above four principles of constructivism through engaging problem-based investigations that utilize Wii gaming. Yet, the goal should be more than just game play. The lessons presented in *Investigating Middle School Mathematics: Classroom Lessons Using Wii Sports* (Gawlik, 2011), provide structure to investigate predetermine middle school mathematics; and they provide freedom to explore questions and problems that arise from students investigating the mathematics and analysis. Students are allotted the opportunity to engage in discourse about the data collected, and

defend their reasoning for predictions based on their experiences of game play. With well thought-out lessons, students can be challenged to generate their own experiments, create hypotheses, and test them. Through open-ended reflective questions, students are allowed to reflect across their experiences and make meaning of the mathematics.

Conclusion

Making mathematics fun for all students can be accomplished through engaging lessons using the popular and affordable Nintendo Wii. Students can investigate mathematic through video gaming, which can provide intrinsic motivation as part of the learning environment. The "act of play" has had a positive effect on student motivation and retention of knowledge than conventional instruction (Sedig, 2008). Teachers that incorporate Wii gaming into their classrooms will be able to create a community of discourse engaged in activity, reflection, and conversation (Fosnot, 2005).

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