Use of the Harkness Method in the Mathematics Classroom

Kyle Botkin

Harvard Extension School

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Introduction

Educators are always searching for an edge to better teach the student populations in their care. This most frequently results in changes to explanations of material or alterations to assignments and activities. For better or worse, the teacher remains at the center of the learning process; their role as the sole "dispenser of knowledge in the classroom [remains] axiomatic to most" in the profession (Geary & Atif, 2013, page 1). Most teachers believe that the most efficient learning happens when they are at the front of the classroom, however, the only reason lecturing is still the norm in today's classrooms is due to "historical anachronism". Throughout most of history, the lecture solved the problem of lack of literacy of the populace. Long before the invention of the printing press, the literate would stand in the front of a lecture hall and read aloud from the few available copies of relevant texts to educate the illiterate (Davis, 2016).

But should this still be the method of choice for education today? Maybe teachers should not be delivering content at all. Maybe further gains are to be made from students learning from one another. This is the supposition of the Harkness method which suggests that "teaching can be more about creating an *environment* that fosters the discovery of content" (Geary & Atif, 2013, page 1, emphasis added).

What seems like every publication, peer-reviewed articles and main stream media alike, has pronounced that math achievement in America is lagging behind the rest of the developed world. Could Harkness teaching, designed almost a century ago, be a solution to this much debated issue?

This paper will describe the Harkness method and its history, followed by a discussion of its advantages and disadvantages. Also addressed are some strategies for its implementation in the classroom.

Harkness' creators strove to find a teaching style in which "a small group of students, seated around a table and guided by an instructor, could best be engaged in learning by voicing their own ideas and questions and listening to those of others. It was a powerful concept whose power has not waned" (Towler, 2006, page 11).

An Overview of the Harkness Method

The Harkness method of teaching is a discussion-based pedagogy in which the teacher and students work together exchanging ideas and information, "interacting with other minds, listening carefully, speaking respectfully, accepting new ideas and questioning old ones, using new knowledge, and enjoying the richness of human interaction" (Geary & Atif, 2013, page 1). Where the Socratic method and other discussion-based teaching styles rely on the teacher to stimulate discussion and disseminate knowledge, Harkness relies on each student's contributions to the conversation and an emphasis is placed on student-centered learning (Smith, 2016). Classroom discourse revolves around students' reactions to and experiences in solving their homework assignments. This means that they must come to class prepared with their work completed and with the confidence to share. By discussing readings and their struggles with assignments, students guide themselves through the curriculum, helping each other address misconceptions. The teacher's main role is in creating effective, thought-provoking problem sets. Like all teaching styles, Harkness is

practiced in various ways across educational disciplines. “The Harkness approach in mathematics is quite different from the Harkness approach in history, and the same can be said for English and science classes. Moreover, Harkness teaching can differ from teacher to teacher within the same discipline, just as discussion can differ from class to class” (Smith, 2016, pages 25-6).

In the math classroom, Harkness teaching involves students solving methodically crafted word problems from which all of the course content is derived: “there [are] no lectures, no worked examples, no summarizing content except in the problem text” (Davis, 2016, page 2). All of the necessary definitions, theorems, and examples are presented in the problem sets, which are carefully designed to build in difficulty and complexity each day, while also introducing new concepts along the way. Accordingly, the Harkness method for mathematics teaching is not only discussion-based, but a problem-based pedagogy.

The problems encourage students to grapple with new ideas and practice learned concepts, while also stimulating subsequent discussions (Schettino, 2003). Exeter’s own materials describe the problem sets as explorations of mathematical concepts (Math teaching materials, 2016). At the beginning of class, students copy their solutions to homework problems from their notebooks onto the board. After presenting their solutions, the class discusses each problem. Each student is expected to add to the conversation by asking questions, commenting on procedures which they may have performed differently, providing clarification of misconceptions, and coming to a consensus when conflicting solutions are reached. They consider how current

problems relate to previous ones and then consider how that information might help in overcoming future difficulties (Davis, 2016).

Two Exeter teachers, Geary and Atif, describe an ideal classroom where students are comfortable making mistakes and correcting each other. They find “what usually results is a lively conversation in which the teacher is on the periphery” (Geary & Atif, 2013, page 3). This is truly the core of Harkness teaching: students learning from one another’s successes and failures.

So what are the advantages and disadvantages of using this style of teaching in the mathematics classroom? And can it even be implemented in a “typical” public school setting? These topics are explored in the sections to come, but first, a bit of history.

A Short History of Harkness and Exeter

The Harkness method was named for businessman and philanthropist Edward Harkness. In 1930, in exchange for a radical redesign of the school’s teaching methods, Harkness agreed to make a substantial donation to Phillips Exeter Academy, whose headmaster, Lewis Perry, was a close friend. The product of a New England prep school himself, Harkness had become disillusioned with the recitation style of education in vogue at the time. The school’s original proposal was rejected as being a mere modification of the present style of teaching. In his own words, Harkness wanted changes “of a fundamental nature that were so sweeping and so different from methods prevailing [at Exeter] that one could see at a glance that, were they adopted, the whole educational system in our secondary schools would not only be changed, but changed

for the better" (Towler, 2006, page 3). The school's second proposal was accepted, and its faculty members set about designing a "conference" style of teaching. Today, the word "Harkness" itself has come to summarize the school's educational philosophy.

Edward Harkness' father Stephen started his career as a harness maker, but soon "became a silent partner in the fledgling oil refining business established by John D. Rockefeller, later incorporated as the Standard Oil Company" (Towler, 2006, page 4). After his father's death, the family continued in their loyalty to Rockefeller and his struggling oil company. Eventually, the gamble paid off with the invention of the automobile. Edward's siblings all died young, and with the death of his mother, he became the sole inheritor one of the largest personal fortunes in America. Harkness devoted his life to systematically giving this fortune away. By the time of his death in 1940, he had "made charitable gifts totaling more than $129 million, the equivalent of nearly $2 billion in today's dollars" (Towler, 2006, page 4).

The history of Phillips Exeter Academy can be divided into two eras: before and after the "Harkness gift." Founded in 1781 by Dr. John Phillips, Exeter was for its first 150 years a typical college preparatory academy (Academy history, 2017). The school had a stern atmosphere of large classes in which its boys were called out by last name, and largely taught by recitation (Towler, 2006). After receiving the "gift," Exeter's faculty spent the next 50 years refining Harkness' ideal of conference-style teaching. In the early 1990s, Exeter's math department decided to move away from the use of standard textbooks in favor of the self-created problem sets still in use today. They spent the next eight years developing, editing, refining, and perfecting them each summer (Geary & Atif, 2013). All of their problems and materials, still being polished today, are now

freely available to download on the Exeter website. This is in line with the spirit of the Edward Harkness' philanthropy, as he "clearly saw his gift to Exeter as only the beginning. It was his hope that the method of teaching he helped introduce at the Academy would become a model for schools nationwide" (Towler, 2006, page 7).

Advantages of Using Harkness

There are many benefits of using Harkness discussions in the math classroom, including fostering problem solving skills, learning through mistakes, and independent thinking. Harkness teaching also supports classroom discourse and student metacognition, and provides real-world application.

First and foremost, use of the problem sets drives students to develop a strategy for problem solving. Through the careful design and sequencing of problems, students learn the rules and formulas of mathematics by discovery (Geary & Atif, 2013). Furthermore, peer interaction and daily discussion of the problem sets trains students in the art of problem solving. They are exposed to different strategies and can implement different ideas to see what works and what does not.

An integral part of the process involves students presenting their solutions and discussing how they solved a problem. By explaining their strategies, students are given the opportunity to teach and learn from one another (King, 2011). This reinforces the fact that students have the freedom to solve problems in many ways, not just the teacher's way or the book's way, and allows them to further expand "their mathematical tool kit[s]" (Schettino, 2003, page 2). Creativity in problem solving follows directly from discussing strategies and learning from peers.

One teacher shared that his students came to value the discussion process so much that they would unknowingly “uncover the solution [during] their lengthy exposition but wouldn't realize they had until the problem statement was read!” (Isgitt & Donnellan, 2014, page 5). Additionally, discussion of the problem solving process directly supports both MP7 and MP8 in the Common Core’s Standards of Mathematical Practice, looking for and making use of structure and repeated reasoning (Standards for mathematical practice, 2010).

Harkness teaching also encourages students to learn from their mistakes, an essential part of learning at deep levels (Smith, 2016). When teachers immediately correct wrong answers and rectify misconceptions, students are never given the opportunity to struggle through their mistakes and come to their own conclusions about why their solutions were incorrect. By creating a supportive, safe environment, conducive to discussion, teachers allow students to “learn from [their] mistakes and adapt their problem solving” (King, 2011, page 73). Perseverance in problem solving is the first Mathematical Practice recommended by Common Core (Standards for mathematical practice, 2010).

Obviously, the Harkness method directly supports discourse in the classroom, which is Mathematical Process Standard three (Standards for mathematical practice, 2010). Discussion and debate produce complex thought processes and cultivate creative solutions to problems. Discourse also hones interpersonal skills. Students “have to find collegial, mature ways to disagree. They have to listen to others, connect points, and police their own conversations. Shy students, while uninspired or terrified by group talks, can build their confidence. Above all, students have to *think*” (Mullgardt,

2008, page 2). Such classroom conversation emphasizes critical literacy: students must be able to express their thoughts and opinions clearly.

Many students involved in classroom discussions about problem solving report increases in their own mathematical confidence as well as having more comfort in discussing their mathematical ideas (Davis, 2016). They also show increased metacognitive ability to evaluate their own skills and identify their strengths and weaknesses (King, 2011). The teacher's ability to track conversation threads can provide clarity as to which students are learning what, and help them to pick up on specific behaviors and trends across their classes (City, 2014).

Because the content is often presented in real-world context, Harkness problem sets can cultivate an appreciation for math outside the classroom. Teachers at Exeter claim that even "experienced math teachers who work through the problems for the fist time discover new ideas and rich connections" (Geary & Atif, 2013, page 2). Upon reviewing exit survey data from her multivariable calculus class taught in the Harkness style, Davis reports that students enjoyed the problem sets more than lecture, and that their enjoyment increased over the course of the term. She also witnessed a higher percentage of her students willing to work on new and different types of problems versus problems they already knew how to solve (Davis, 2016). Enjoyment of math and the ability to see its usefulness are important factors in student motivation and performance.

Finally, and maybe most importantly, Harkness conversations foster independent thinking. Many students struggle and lose confidence with problems that differ even slightly from those they have already seen. They are "conditioned to receive answers

from teachers rather than discover new relationships independently" (Isgitt & Donnellan, 2014, page 3). Most teachers have heard students claim that they learn better when procedures are just given to them, but true understanding and proficiency in math comes when students are able to recall an idea on their own and apply it to a new situation, and not merely repeat the same process (Schettino, 2003). Two teachers at Exeter have even defined Harkness teaching as discussions which help students "to make the discoveries for themselves, to get them to draw their own conclusions, to teach them how to consider all sides of an argument, and to make up their own minds based on analysis of the material at hand. Harkness teaching tries to develop in students their own sense of responsibility for their education" (Smith & Foley, 2009, page 3). Fostering independent thinkers and allowing curiosity to drive the engine of education are truly at the heart of the practice of Harkness.

Non-Mathematics Related Benefits

There are two other specific, non-mathematic benefits to using Harkness in the classroom. First, debate in the math classroom encourages students to view cross-curricular courses as reinforcements of each other and can help "remove some of the traditional walls that schools place between STEM and humanities courses" (Isgitt & Donnellan, 2014, page 6). The idea that their various classes are related — that problem solving can be used in language and humanities courses, and that literacy is vital to mathematical and scientific discoveries — can support students in the move from the mindset that they are simply learning a set of disparate facts to a mindset that all education is worthwhile and necessary for their growth.

Secondly, students in problem-based classrooms report increased confidence while speaking in front of an audience, as well as showing increased aptness to ask relevant questions. As "standing up and presenting in front of other people is a highly valued skill" in the workplace, the presentation of solutions in class gives students the opportunity to practice and refine this important job competence (Davis, 2016, page 6). One of Exeter's messages to their students is that the "ability to communicate ideas [is] just as important as getting the correct answer" (Math teaching materials, 2016). Many students question the real-life usefulness of their mathematics courses, but they would be hard-pressed to find a job in which discussion, problem solving, or presentation aren't vitally important for advancement. Use of the Harkness method makes the mathematics classroom relevant even for those students who claim that they will never use mathematics in the "real world."

Drawbacks and Potential Pitfalls

In addition to the advantages, there are some drawbacks of using the Harkness method as well. These include the lack of foundational education, concerns over classroom size and heterogeneity, and teacher and student ability. The concurrent use of technology and a propensity for subjective grading are also worries voiced by dissenters.

Many detractors claim that students need the foundation provided by teacher-led lectures or activities before being able to effectively discuss exploratory problem sets. This creates a "base of knowledge" or a "well of information" that students can access during discussions (Smith, 2016, page 41). Students' abilities and maturity levels play a

role in this as well, as classroom structure is built around discussions being student-centric. One of the most common concerns stated by public school teachers is the claim that boarding school students "are all smart, but less able students from another school could not possibly carry on a discussion as well" (Smith & Foley, 2009, page 17). Extending beyond foundation, many students are accustomed to regular practice and review in applying newly learned mathematics ideas and topics (Schettino, 2003). Discussion based curriculums do not always specifically provide practice or review.

Preparatory schools are also often afforded the advantage of having smaller classroom sizes. Larger classrooms and different school cultures can be an impediment to the implementation of Harkness. One private school teacher using Harkness in the classroom claims that "16 is really a maximum for this type of instruction" (Mullgardt, 2008, page 2).

Prep schools also typically have more homogenous classes when it comes to ability levels. In public schools, where classroom make-up often varies greatly, it can be much more difficult to meet the needs of all students. Weaker students might need to spend more time discussing foundational topics, while more advanced students want to move on to trickier, more involved problems (Davis, 2016). If the teacher defers to one student population or the other, students are either left behind or become increasingly bored. This can lead to disillusionment for mathematics in both cases.

Comfort with the material is another obstacle reported by teachers when first putting discussion-based classroom strategies into action. Teachers must be quick on their feet and ready for the possibility that students will present ideas or come up with solutions which had not been considered beforehand (Schettino, 2003). Being

"pedagogically isolated" is another concern reported by teachers implementing discussions in a school where it is not the norm (Smith & Foley, 2009). Without other faculty members to discuss concerns and strategies with, teachers might struggle with classroom problems or abandon discussions altogether. For example, one teacher reported students deciding "they had 'the right to remain silent,' saying that [discussing mathematics] was cruel and unusual punishment…" (Mullgardt, 2008, page 1). Practicing a classroom structure different from the convention at a particular school can easily cause discussions to become chaotic, so teachers must be clear in their articulation of procedures and guidelines.

The literacy skills necessarily involved in a discussion-based classroom can be another pitfall of using the Harkness method. Even students proficient in English can misinterpret word problems because of little-used vocabulary and words with multiple meanings, and can sometimes struggle to put their thoughts into words. Harkness teachers Isgitt and Donnellan report that sometimes even high-achievers struggle to transfer complex understanding of a topic from one day to the next (Isgitt & Donnellan, 2014). English-language-learners and special education students are at an even greater disadvantage in decoding word problems and discussing their solutions.

As more school districts and education agencies advocate for the increased use of technology in classrooms, it can be hard to justify the use of an antithetical curriculum. Student use of computers or tablets in class by nature encourages "isolation and individuality, which promotes behaviors contrary to participation in class discussion" (Smith & Foley, 2009, page 16). Administrators may also be leery of teachers using discussion as the delivery method for content because it "is rarely as

efficient as lecture" and because of the perceived unpredictability of how much of the prescribed curriculum is completed each school year (Smith & Foley, 2009, page 18).

Grading is an important topic brought up by dissenters. The scoring of discussion participation contains "an element of subjectivity, which can lead to discrepancies in the consistency of grades" (Smith, 2016, page 115). When grades are attached to discussion, teachers might inadvertently penalize shy students, cause anxiety or competition over speaking time, or even "chatter for the sake of chatter in hopes of a high grade" (Mullgardt, 2008, page 2). In the same vein, Davis' implementation of Harkness in a college-level multivariable calculus class saw "no systematic difference in exam scores under the two methods [lecture and discussion-based]" (Davis, 2016, page 5). If there is no quantitative difference in student achievement, critics wonder if it is really worth the time and effort involved in implementing Harkness in the mathematics classroom.

The Implementation

Implementing the Harkness teaching style requires more work from the teacher at the beginning of the school year in order to establish classroom procedures and polish problem sets. "Assuming responsibility for the success of the class does not come easily or naturally to most students," so teachers should not expect the process to happen overnight (Smith & Foley, 2009, page 11). Conversations about class mechanics and training students how to effectively discuss and debate must take place early in the term.

During this foundational period, teachers must be flexible in their lesson planning, carefully weighing the difficulty of problems and expectations for participation. Most importantly, the teacher must create a welcoming and safe classroom atmosphere. “You can’t possibly have a conversation in which learners will risk expressing their ideas if they feel they might be attacked” (City, 2014, page 3). During discussions, teachers may contribute by offering leading questions when the class is stuck, but students must be aware that the responsibility is ultimately theirs to come up with solutions (Geary & Atif, 2013).

Many teachers struggle with the idea of losing control of the dispersal of knowledge in their classrooms. To remedy this, it is possible that Harkness discussions can be used in conjunction with the practice of the flipped classroom. Teachers record lectures and post them to a class website and students have the option of watching these lectures to support them in completing problem sets. This could be an effective way to supplement classroom discussions and fill in any gaps that aren’t addressed by students’ conversations.

One calculus teacher laid out a five step format for successful discussions in his classroom: exposition, problem statement, road map, solution, and extension. In the exposition step, students discuss everything they know about a topic or problem. Then they dissect the problem statement to determine exactly what is being asked. Before being released to solve a problem, students discuss possible road maps toward a solution so that everyone knows what is expected of the them and has a starting point for their work. The final two steps are actually solving the problem and, given time, a discussion of related extension problems (Isgitt & Donnellan, 2014).

Mullgardt, another practitioner of Harkness, has five suggestions for teachers trying classroom discussions for the first time. He recommends trying to find other teachers in your building who are willing to try, or have already put into practice, discussions in their classrooms. Teachers should post essential discussion questions ahead of time; don't surprise students with questions they are not prepared to discuss. Don't be afraid of silence, it rarely means that no thinking is taking place (quite the opposite in fact!). He recommends that teachers place some kind of grade on discussions to motivate all students to participate. And finally, "do it frequently, or forget it." Discussions do not need to take place every day, but on the other hand, only a few times a month is not enough exposure for students to become comfortable with the process and see valuable returns from it (Mullgardt, 2008, page 2).

Though much of the teacher's efforts are front loaded, complete problem sets are available on Exeter's website free to download, and there are many other resources available online or in print to support teachers in this classroom philosophy.

In Conclusion

It is my opinion that the advantages of Harkness teaching outweigh the disadvantages; beyond the math curriculum, students need to be given the opportunity to problem solve and really think for themselves. They need to learn how to work cooperatively and disagree respectfully. Using the Harkness method can help students develop these skills.

I would modify the method if attempted in my own classroom. I would seek to only have full-class discussions one or two days a week. The remaining days could be

filled with small group problem solving activities, practice of skills, and teacher-led introduction to new material to try to address the needs of providing a foundational education and review.

Harkness “is neither a teacher-proof curriculum, nor a curriculum-proof method” (Davis, 2016, page 11). It is, just as all teaching styles, not for every educator. It completely depends on the teacher’s strengths as a moderator, their capacity to effectively establish classroom norms, and their ability to pose deep, thought-provoking questions.

Some further questions that were not answered in my research that I would need addressed before diving into this type of teaching are: How should students be assessed? Should the same exams be used as with classes of typical, lecture-based instruction? Could Harkness be used in conjunction with standards-based grading?

As there is very little peer-reviewed research on the use of Harkness in public schools, I am curious if the method can really be achieved, as intended, in these classrooms. Can public school students be expected to dig into a problem set of eight to ten involved questions each night for homework? In my experience as a teacher, this much homework would receive pushback from both parents and administration. Use of the flipped classroom and taking the day before discussions to have students work through a problem set in class could resolve the homework situation.

With the attention span of millennial-age students sharply decreasing, maybe a teaching philosophy based on the discussion of interesting problems is an even better idea today than it was in 1930. After all, Edward Harkness “had in mind nothing less than changing the face of education” (Towler, 2006, page 4).

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