BILINGUAL PUBLISHING GROUP

Journal of International Education and Practice

https://ojs.bilpubgroup.com/index.php/jiep

ARTICLE

Adapting the Concept Attainment Strategy to Teach Math

Khodadad Kaviani*

Department of Education, Central Washington University, United States

ARTICLE INFO

Article history
Received: 15 January 2023
Accepted: 20 February 2023
Published: 02 March 2023

Keywords:
Assessment
classifying
Graphic organizer
Constructivist
Teaching strategy

ABSTRACT

This paper argues for the adoption of concept attainment strategy when teaching math and shows the structure of this curriculum design that can substantially improve math instruction and comprehension in K-12 education. Initial findings based on informal surveys of teacher candidates indicate many of them do not have a clear understanding of the concepts they are expected to teach. The concept attainment strategy is a proven effective method used in social studies for teaching powerful concepts like democracy and liberty. One reason for many students feeling inadequate about their math skills stem from their lack of understanding of the key math concepts like area, perimeter, percent, and others. Poor understanding of the math fundamentals in early grades if not rectified, develops into a dislike for an incomprehensible subject. The concept attainment strategy is an inductive approach that allows the students to participate in knowledge construction and master the fundamental math skills. This paper shows how the structure of this social studies curriculum design can be adapted for teaching mathematics and invites practitioners and scholars to consider this approach to improve math instruction.

1. The Problem

"I'm not good in math" is the mantra I hear from most of the teacher candidates that are enrolled in my math methods courses at a major university in the Pacific Northwest. It is as if these teacher candidates have already made up their minds that they will never become good in math and their efforts in learning math are futile. I have been shocked to see teacher candidates who did not know the difference between area and perimeter, and they were expected to teach math when they earned their teaching certificate. Richards (2020) reports that the United States of America ranked "31st in math literacy out of 79 countries and economies" in the international exam given to teenagers. Based on the informal surveys I have conducted at the beginning of each academic term and the conversations I have had with the teacher candidates in my classes, it is clear to me that most of them have math anxiety and feel unsure whether they can master the skills necessary to become effective math teachers. Therefore, the claims I make in this paper are based on my observations of the teacher candidates I have been working with and their direct feedback to me regarding their experiences.

To build their confidence and provide opportunities for them to practice their math skills, I have relied heavily on math games that use selected math algorithm (e.g., steps involved in solving addition, subtraction, multiplication, and division problems) while collaborating with their peers. They appear to enjoy the process and find card and dice games can teach math content and fluency by emphasizing targeted mathematical skills that they can

**Corresponding Author:*
Dr. Khodadad Kaviani, Department of Education, Central Washington University, United States; Email:khodi.kaviani@cwu.edu.

 DOI: https://doi.org/10.30564/jiep.v6i1.5404

learn and practice together. In addition to gaining content knowledge, they also rehearse their social skills by taking turns answering questions, listening to each other, sharing their answers, cooperating with each other in maintaining the score sheet, and resolving issues that may arise during the friendly and competitive math games. They also practice higher order thinking skills when choosing a strategy, prioritizing their actions, verifying their answers, and so on.

The literature on gamification supports the claim that online math games were utilized by teachers during the COVID-19 pandemic to motivate children to practice certain math skills related to recognizing patterns, mathematical operations, and others (Lavidas, Apostolou, & Papadakis, 2022). The shift from in-person attendance to online classes added self-paced virtual math games to the resources that teachers were using. Children's misconceptions about number sense and how different operations produce new numbers are among the reasons for using games and manipulatives to clarify math meanings (Hulse, Daigle, Manzo, Braith, Harrison, & Ottmar 2019; Clements, 2000; Doig & Ompok, 2010; Shute, 2011). Sun-Lin and Chiou (2019) found that sixth grade algebra students were able to not only improve their confidence in solving algebraic story problems, but also scored higher in a gamified environment. Watson-Huggins and Trotman (2019) conducted a quantitative study at a primary school in Jamaica that showed students who used games to learn math had higher math scores and increased motivation with the subject than the controlled group.

The gamification of mathematics teaching is a viable strategy that can help students overcome their math anxiety and become more confident in their abilities to solve certain types of math problems. All games have rules that need to be understood and followed by all the players which are like the abstractions found in teaching multiplication, division, and other mathematical operations. Decoding symbols and applying the right algorithm are necessary when solving math problems. As a person who learned English as my second language, I find many similarities between learning a new language and mastering the skills necessary for solving math problems. In both subjects, words have loaded meanings and those meanings are socially constructed. Understanding the words makes it possible to decode the text. I often remind my students that math should be treated like a foreign language that can be understood if we know how to decipher the abstract codes correctly and translate the words and symbols. Mastering the mathematics requires "precise and accurate language" (Hughes, Powell, & Stevens, 2016, p. 13) which translates into paying closer attention to how ideas are spoken in a math class by using appropriate academic language like vertex instead of point or minute hand instead of long hand, etc. I propose embracing the concept attainment strategy as a viable curriculum design option in K-12 math education to ensure important math concepts are taught properly, and students are given the necessary scaffold to perform at the top of their abilities within a clearly defined structure. Next, I explain how the constructivist approach of concept attainment strategy can improve math instruction, leading to increased fluency and deeper understanding of the math concepts.

A Novel Approach

How should teachers teach key concepts like percent, function, area, perimeter, Greatest Common Factor, and others that are fundamental in math education? Two constructivist approaches that I advocate are from the social studies discipline, and they are called concept attainment and concept formation (Parker, 2012). These curriculum design approaches are constructivist in nature. They are credited to a curriculum theorist and education reformer named Hilda Taba, who argued, "No one should be asked or induced to try to do what he cannot be taught or be helped to learn how to do" (Taba, 1962, p. 462). What makes Taba's approach unique is the recognition that when teachers overwhelm their students with too many details, the students cannot make the necessary connections between the new information and what they have already learned. Thus, relying on rote memorization becomes necessary in the absence of fully understanding the concepts derived from specific examples.

In this paper, I focus on the concept attainment model (Parker, 2012; Sunal & Haas, 2005) borrowed from the social studies discipline because it is more straight forward and less time consuming to use in the classroom. I have been using this model in my social studies method courses for years. I have recently decided to teach this model to my undergraduate students to see if their misconceptions about certain math concepts could be remedied and boost their confidence. Based on the verbal and written comments I received from them throughout the term, it was clear that this way of learning was new to them, and they were challenged by it. The deep learning that occurred was due to the rigor embedded in the built-in assessments that accompanied this effective teaching strategy. The teacher candidates who experienced this form of constructivist approach to learning, remembered their involvement in the lesson and could recognize and articulate the essential features of the concept that they had studied. Let us examine the details of this curriculum design.

DOI: https://doi.org/10.30564/jiep.v6i1.5404

2. Concept Attainment Strategy

The concept attainment strategy uses an inductive approach that relies on studying specific examples of a given concept and distinguishing it from nonexamples, before developing a relevant theory for the examples observed in different settings. A concept is an idea, sharing common attributes that without one of its key attributes, the concept loses its status and becomes a nonexample. To help visualize a nonexample, one can think of a violation that may happen during the game of volleyball. If a player holds the ball for too long or touches the net with their body, then it is foul.

The concept attainment model follows a clear and methodical path that is logical and engaging. However, the challenging parts of this curriculum design starts with establishing the main features of the concept based on reliable sources. This means, the teacher needs to become a researcher and consult reliable sources (e.g., dictionaries, encyclopedia, scholarly articles, etc.) that define the concept under examination. Next, they need to synthesize those four to five researched descriptions into one coherent definition of the concept with the main features highlighted. Finding clear examples that have all the essential characteristics of the concept is a must, so that the common threads shared among the examples are exposed. Furthermore, finding nonexamples that lack at least one key characteristic is not an easy task.

I have found the teacher candidates have difficulties in establishing the critical attributes of the concept they want to teach (e.g., prime numbers, equivalent fractions, etc.) because it requires careful reading of the various definitions that exist in multiple reliable sources like dictionaries and math textbooks. They are not used to questioning the descriptions from various sources and synthesizing them into one coherent sentence.

This model of teaching is very precise and language sensitive. Therefore, it becomes necessary to find out how a chosen concept has been defined by reliable online and/or print sources. The first place to read about the origin and history of the word should be the online etymology dictionary at etymonline.com. Next, dictionaries and encyclopedias should be consulted. Finally, additional research is needed to document how scholars and experts in the field have used the concept in their peer-reviewed published work in reputable journals. With all this data, a clear definition for the chosen concept can be written with each of the essential attributes distinguishable from each other. For instance, in fourth grade the concept of percent is introduced and here is what I came up with for its main features. Percent is a number (1) expressing a ratio (a part of something) (2) compared to 100, (3) that are equal segments, (4) and using the percentage symbol % that is equivalent to hundredths.

Next, these main features of percent are used to create "Focus Questions" (Parker, 2012, p. 321) that students can use to record and organize their answers when studying flawless examples of percent. Choosing examples that are clear and easy to understand is important in this phase of the lesson design. I present each example and evaluate it based on the listed Focus Questions that target the uncompromising features of percent. These examples are from local grocery store advertisements, online shopping, discount offers by car dealers, news stories, stock market data, and other sources that report on real world events. This segment can be seen as the "I do" and "We do" parts of the lesson development where the teacher presents three to five flawless and clear examples of percent that come from everyday life. One such example could be this: Dave saves 27 dollars out of 100 dollars he earns from babysitting. Can we use % to show this relationship?

The students need to see a few nonexamples of percent too. For a nonexample to exist, all required is at least a clear absence of one of the essential features of percent (e.g., not a ratio, unequal parts, or not compared to 100). A similar graphic organizer is used to show the absence of at least one main feature of each nonexample under examination. I would present each of the nonexamples and explain the reasons for why "F" and "G" are nonexamples

Table 1: Graphic Organizer with Focus Questions for the Concept Percent

Examples	Is this a ratio? Explain.	Does it compare a number to 100? Explain.	Are the divided parts equal? Explain.	Can % be used to represent this ratio? How?
Saving $27 out of $100 earned.	Yes, because it compares money saved to total money earned.	Yes. $27 is compared to $100.	Yes. The total amount is divided into 100 one-dollar bills.	Yes. 27% = 27/100 = 0.27 of every dollar saved, or 73% = 73/100 = 0.73 of every dollar spent.
B				
C				
D				
E				

 DOI: https://doi.org/10.30564/jiep.v6i1.5404

of percent. Finding nonexamples can be challenging. One such nonexample can be a whole pizza that is cut into five unequal pieces, making it impossible to claim that a piece is 20% of the whole pizza (Figure 1).

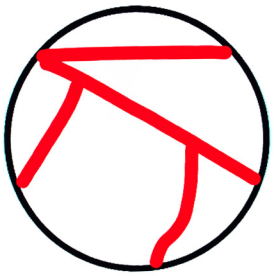

Figure 1: A pizza cut into five unequal pieces

Table 2: Graphic Organizer with Focus Questions for the Concept Percent

Nonexamples	Is this a ratio? Explain.	Does it compare a number to 100? Explain.	Are the divided parts equal? Explain.	Can % be used to represent this ratio? How?
F				
G				

By this point in the lesson, I have introduced 3-5 flawless examples of percent along with two nonexamples. One can say, this lesson has been introduced adequately, but what about student learning? Have the students learned this concept? Can they explain percent in their own words?

To provide additional opportunities to study percent by reinforcing its main features, students are challenged by four "classifying" (Parker, 2012, p. 322) activities. Each of these classifying activities can be seen as "You do" assessment that helps the student clarify any misconceptions they may still have regarding percent. Teachers can also see which students are still struggling with understanding the concept and need additional practice by monitoring what the students write in their graphic organizers.

3. Assessment: Four Types of Classifying

In this part of the lesson, students' understanding of the concept is deepened by engaging them in four types of classifying activities that checks their comprehension of the concept and invites them to showcase their knowledge of percent in different ways.

Classifying Type 1: In this assessment, I present one scenario to my students and ask them to evaluate it based on the main features they have been learning about. Then, I ask them to justify their answers as they work independently or with a study buddy to determine whether this single item is an example of percent by answering the Focus Questions. The graphic organizer developed for this purpose is an essential part of providing the necessary scaffold for the students to organize their answers (see Table 3).

It is important to use neutral language like scenario, situation, story, item, or problem when presenting the case to the students for classifying. A common mistake novice teachers make during the assessment phase of this model is using the word "example" which is a giveaway of the answer. The mistake looks like this: "Study this example and tell me if it is an example of percent." The correct way of asking the question is: "Study this problem and tell me if it is an example of percent. Be ready to justify your answer based on the Focus Questions." Teachers should be using a neutral language so that the student decides how to classify it as an example or a nonexample of percent. In other words, by not paying attention to the labelling when presenting this problem to the students, the teacher may confuse the students by already classifying the task for them.

After sharing their answers with their study buddies, I call on volunteers to come up to the board and present their answers to the class. This segment can be seen as the "You do" part of the lesson presentation where students

Table 3: Graphic Organizer for Classifying Type 1

Single Item	Is this a ratio? Explain.	Does it compare a number to 100? Explain.	Are the divided parts equal? Explain.	Can % be used to represent this ratio? How?
Adam collected one hundred candies of different sizes when he went trick-or-treating. He ate three candies. How would you express the number of candies eaten vis-à-vis the entire stash?	Yes, because the question is asking about the ratio of eaten candies to the entire stash.	Yes, the problem is comparing 3 to 100.	Student A: Yes, because the unit of measurement is candy. Student B: No, because some of the candies were smaller than the others, and we don't know enough about the candy sizes.	Student A: Yes. 3% =3/100 = .03 Student B: I'm not sure. The candies had different sizes.

DOI: https://doi.org/10.30564/jiep.v6i1.5404

can assess their understanding of percent. It is important to listen to the justifications offered by the students when answering the Focus Questions. In Table 3, I have provided a sample for two different answers for the third and fourth attributes of percent. The rich conversation generated in the classroom regarding these answers help deepen students' understanding of percent.

Classifying Type 2: I present a minimum of three items for the students to classify based on the main features of percent. I would say, "Please study these problems and tell me which ones are examples of percent. Be sure to warrant your claims based on the main features of the concept." These problems are a mix of examples and nonexamples taken from real life situations (e.g., grocery advertisements, shopping coupons, news events, etc.). It is important to always ask students to justify their answers and defend their decisions based on the established key characteristics of the concept. They can work by themselves or in small groups when making their decisions. The conversation generated during this exercise is not trivial because students learn to discuss math when translating abstract ideas and symbols into spoken academic language. They are learning to support their claims with evidence. The graphic organizer used for this assessment can showcase how the students have understood the concept. (see Table 4).

Table 4: Graphic Organizer for Classifying Type 2

Mixed Items	Is this a ratio? Explain.	Does it compare a number to 100? Explain.	Are the divided parts equal? Explain.	Can % be used to represent this ratio? How?
I				
J				
K				

Classifying Type 3: During this phase of continued assessment, I ask my students to produce an example of percent by inventing or finding an example of percent from selected online sources or print advertisements that are made available to them. What they produce can be a poster, a story problem, an advertisement, or other mathematical expressions or sentences of their choosing. Once again, I ask them to justify their answers by evaluating their answers based on the Focus Questions that are tied to the main characteristics of percent.

Classifying Type 4: This classifying activity is about turning a nonexample of percent into an example. Imagine we had a partial pizza that was cut into different sizes and shapes that was impossible to determine the percentage of each piece compared to the entire pizza. For instance, I would ask my students to think about the changes that they would make to this chopped up pizza so that a given percent (e.g., 20%, 25%, etc.) can be accurately shown. I remind my students to always justify their decisions based on the Focus Questions that are tied to the main features of the concept. I call on my students to share their work in small groups before presenting their answers to the whole class. One approach is asking all the students to stand up and form two rows facing each other. Then, they can explain to each other the changes they recommend for turning this nonexample into an example of percent. This kinesthetic approach gets them out of their seat to interact with their classmates.

Limitations and Future Research

There are three main factors that limit the claims of this study. First, the concept teaching as described in this paper needs to be understood and duplicated by other math teachers and researchers to see if they can replicate my results in formal longitudinal studies. Second, the findings are based on the information my students provided voluntarily as a part of their assignments. Third, the anecdotal evidence presented in this paper comes from a relatively small sample of the 61 teacher candidates over a six-month period. Thus, additional formal studies can build upon these initial findings to see the extend of success that other math instructors may experience by using the concept attainment strategy.

4. Discussion

There is no quick solution to improving children's math skills in the American public schools. Teachers are the educational leaders in their classrooms, and it is expected that they know the math they are expected to teach. Games can help reinforce the concepts the students have learned. The concept attainment strategy can provide the necessary foundation for deep learning that games alone cannot provide.

An important message of this paper is about advocating the use of the concept attainment strategy in teaching key math concepts. Math and social studies go together, and it is time for math teachers to test this proven strategy that is not new to experienced social studies teachers who teach about what is common good and what is democracy. I have not seen this strategy taught or used by math teachers in my professional experience.

Based on the anecdotal evidence I have gathered during the last two quarters I am convinced that this teaching strategy can benefit math teachers and their students, because it forces the teachers to have a deeper

 DOI: https://doi.org/10.30564/jiep.v6i1.5404

understanding of the concept themselves before trying to teach it to their students. It is not reasonable to expect math teachers to teach concepts that they do not know well. I have seen the marked improvements in the attitudes and skills of the teacher candidates that I have taught. I have seen their confidence grew as they clarified their own misconceptions with the concepts that they chose to teach. I met with them individually and in small groups to answer their questions regarding the critical attributes of their concepts and the classifying activities they planned to use in their lessons. Lasting confidence happens by acquiring the necessary knowledge and skills that come from hands-on experiences and applying those learned skills to new situations. It would be ideal to follow up with these teacher candidates after they have become elementary school teachers to see how exposure to this teaching strategy influenced their confidence and competence when teaching math.

Concept teaching is not easy. However, it should be a viable option for math teachers so that they can add this strategy to their repertoire of teaching methods. This constructivist approach to teaching and learning advocates deep learning, instead of rote memorization.

Concept attainment follows a rational model that is step-by-step and at each level, students have a chance to test their understanding. They also have a direct personal experience with the knowledge construction through the four types of assessments that exemplify the best form of learning.

There is no question that card and dice games can bring some excitement to math classrooms and make math fun and accessible to reluctant learners. However, the concept attainment strategy offers something more. It offers a proven approach to engage children in math conversation with each other that demystifies the language of mathematics. Speaking mathematics is empowering and all children can learn to speak math.

The concept attainment strategy offers a logical and practical approach to showcasing real-world examples of math that are used in the economy and our daily lives. The teacher candidates that I have worked with have good intentions and kind hearts. They want to teach and help all children learn. What they also need are the necessary pedagogical skills to design effective lessons that are inclusive, empowering, and practical. What I have presented in this paper shows how math teachers can benefit from a powerful strategy that social studies teachers have been using with success when teaching about complex concepts like the common good and democracy. It is time to integrate this effective social studies method into teaching math.

References

Clements, D. H. (2000). 'Concrete' manipulatives, concrete ideas. *Contemporary Issues in Early Childhood, 1*(1), 45–60.

Doig, B., & Ompok, C. (2010). Assessing young children's mathematical abilities through games. *Procedia - Social and Behavioral Sciences, 8,* 228–235. https://doi.org/10.1016/j.sbspro.2010.12.031

Hughes, E. M., Powell, S. R., and Stevens, E. A. (2016). Supporting clear and concise mathematics language, instead of that, say this. *Teaching Exceptional Children,* 49(1), 7-17.

Hulse, T., Daigle, M., Manzo, D., Braith, L., Harrison, A., & Ottmar, E. (2019). From here to there! Elementary: a game-based approach to developing number sense and early algebraic understanding. *Educational Technology Research Development, 67, 423-441* https://doi.org/10.1007/s11423-019-09653-8

Lavidas, K., Apostolou, Z., & Papadakis, S. (2022). Challenges and Opportunities of Mathematics in Digital Times: Preschool Teachers' Views. *Education Sciences*, *12*(7), 459. MDPI AG. Retrieved from http://dx.doi.org/10.3390/educsci12070459

Parker, W. C. (2012). *Social Studies in elementary education* (14th ed.). Pearson.

Richards, E. (Feb. 29, 2020). Math scores stink in America. Other countries teach it differently –and see higher achievement. USA Today. https://www.usatoday.com/story/news/education/2020/02/28/math-scores-high-school-lessons-freakonomics-pisa-algebra-geometry/4835742002/

Sunal, C. S., & Haas M. E. (2005). *Social Studies for the elementary and middle grades* (2nd ed.)Pearson.

Shute, V. J. (2011). Stealth assessment in computer-based games to support learning. *Computer games and instruction, 55*(2), 503–524.

Sun-Lin, H.-Z., & Chiou, G.-F. (2019). Effects of Gamified Comparison on Sixth Graders' Algebra Word Problem Solving and Learning Attitude. Educational Technology & Society, 22 (1), 120–130.

Taba, H. (1962). *Curriculum development: theory and practice*. Harcourt Brace Jovanovich, Inc.

Watson-Huggins, J., & Trotman, S. (2019). Gamification and motivation to learn math using Technology. *The Quarterly Review of Distance Education, 20(4), 79-91.*

DOI: https://doi.org/10.30564/jiep.v6i1.5404