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Exploring Grades 3-5 Mathematics Activities Found Online

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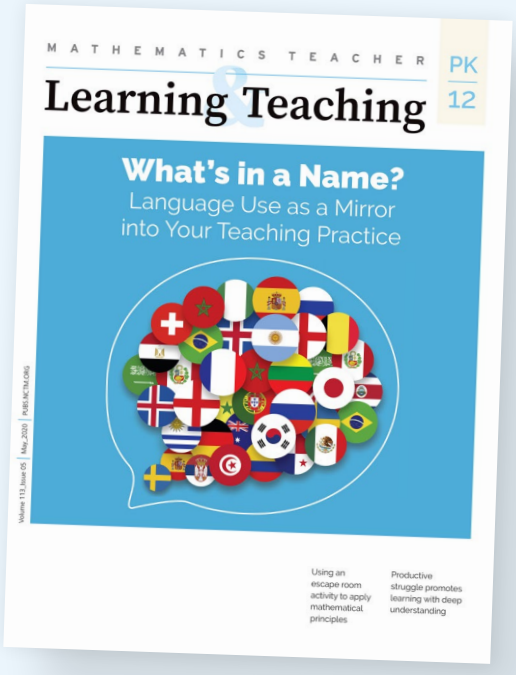


NCTM NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Exploring Grades 3–5 Mathematics Activities Found Online

We investigate resources on TeachersPayTeachers and discuss how what is available affects our teaching practices.

Lara K. Dick, Amanda G. Sawyer, Margaret MacNeille, Emily Shapiro, and Tabitha A. Wismer

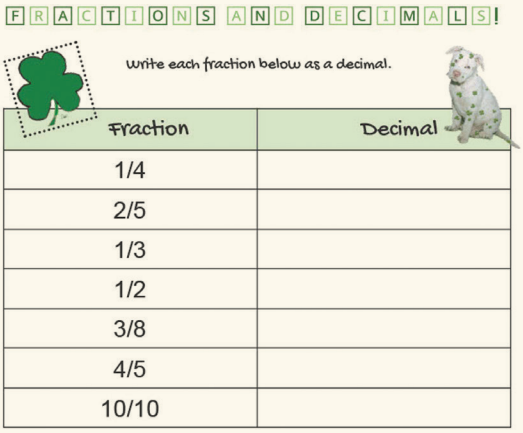
Let's say you are a Grades 3–5 teacher in search of an activity sheet on different fraction notations. A search in May 2022 on the popular resources sharing site TeachersPayTeachers (TpT) yielded 2,832 results, 105 of which were free. With so many options, how would you go about choosing a resource for your students? What would factor into your decision? How would your learning goals, mathematics standards, or other factors influence your choice? How much would you consider visual appeal? Would cost affect your choice? We believe asking these types of questions when searching for and choosing or adapting resources is extremely important.

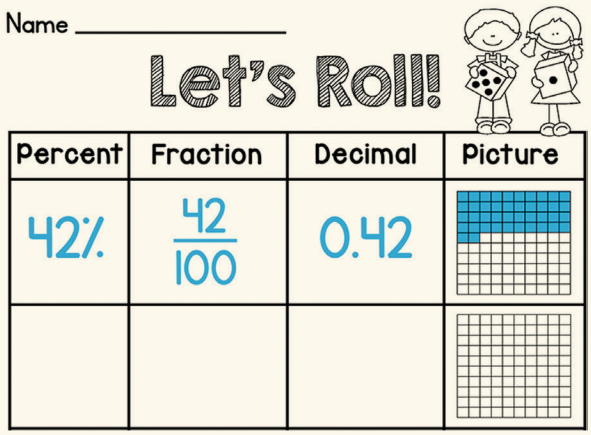
The following two examples highlight some of the different activity sheets found when doing this search (see Figure 1). Both focus on representing fractions in various forms. Activity 1 is free, is decorated for St. Patrick's Day, and emphasizes two types of fraction notations. A teacher might choose it in March to focus students on commonly used fractions and their decimal equivalents. Activity 2 is for sale, is decorated with children holding dice, emphasizes three types of

fraction notations along with a visual representation, and is part of a packet with additional matching and cut-paste activities. A teacher might choose it for its options of ways to focus on multiple representations with visual connections.

Although this is a made-up example, it highlights a growing phenomenon. Following the rise of online teacher-created resource-sharing sites such as Amazon Ignite, Pinterest, and TeachersPayTeachers, the availability of teacher-created mathematics resources has increased exponentially, leading many teachers to supplement their district-supplied curricula (Silver, 2021). According to Silver (2021), "Teacher curriculum supplementation is massive in scope" (p. 5). Teachers and the

Figure 1 Comparing Two Activities





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resources they post on these sites have tens of thousands of user ratings, comments, and reviews. When searching for resources, teachers are inundated with options, but not much is known about these resources regarding the overall breadth and depth of what is available for elementary mathematics. As a result of the rise in their usage, our research team of undergraduate students, practicing teachers, and mathematics teacher educators has completed an in-depth investigation of elementary mathematics resources that appear most often.

As part of a larger investigation in 2018, our team surveyed elementary school mathematics teachers across the United States; we received 602 responses from 48 states and one U.S. territory. Of the respondents, 99% reported that they regularly used online mathematics resources in their classrooms. The most frequently reported site was TpT, with 89% of the teachers reporting its use (Shapiro et al., 2019). Because this was the most popular website reported, we investigated various aspects about the Grades 3–5 elementary school mathematics resources that first appeared in a search. We considered not only the mathematics topics covered in the resources and their visual appearance, but also their cognitive demand and the role of the price of the resource. Our goal in sharing what we learned is to help you, as teachers, understand the limits of these types of sites to assist you in making informed decisions when searching online.

WHAT IS MEANT BY COGNITIVE DEMAND?

O'Donnell (2009) suggested the importance of considering how cognitively appropriate resources are for students. One way to do this is to categorize them on the basis of their cognitive demand, which means considering the "extent to which tasks were set up and implemented in ways that engaged students in high levels of cognitive thinking and reasoning" (as cited in Stein & Smith, 1998, p. 344). Stein and Smith's (1998) four-category task analysis guide (TAG) is a tool that can be used to determine how much a resource requires the students to think mathematically. The TAG contains four levels of cognitive demand: Memorization, Procedures Without Connections, Procedures With Connections, and Doing Mathematics. When a task requires little to no mathematical explanation or thinking, it is considered low demand; low-demand tasks are called Memorization and Procedures Without Connections. Memorization tasks focus on quick recall; Procedures Without Connections tasks tend to be algorithmic and can be solved with a rote procedure. In contrast, when a task requires students to connect their actions to mathematical concepts, the task is considered high demand. High-demand tasks are called Procedures With Connections and Doing Mathematics. Procedures With Connections tasks focus on multiple representations and making connections between algorithms and the underlying mathematical concepts. Doing Mathematics tasks are considered the highest level of cognitive demand, partly because they cannot be solved by applying a procedure. Table 1 includes a detailed description and examples of resources at each of the levels. O'Donnell suggests teachers use TAG as a tool to find "a balance of problems from each category with the hope that students will develop conceptual and procedural understanding" (2009, p. 122), which we interpret to mean that an equal dispersion of demand would be ideal, or approximately 25% of resources at each level. To reiterate, depending on learning or performance goals and where students are in a progression of learning, resources should be provided to students at each of the four levels.

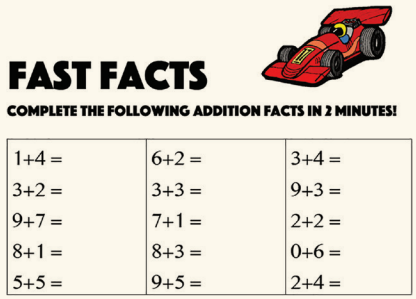
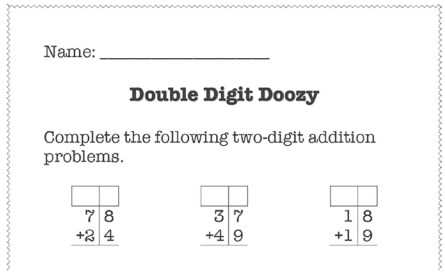
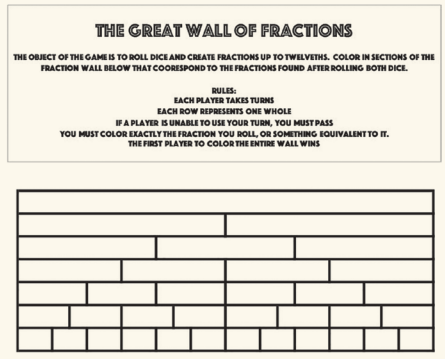
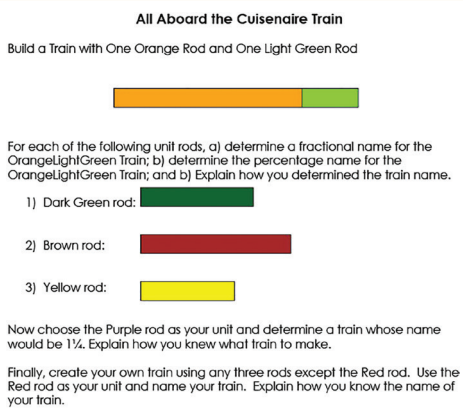
Oftentimes a single resource may challenge students with varying levels of cognitive demand. For example, a geometry activity sheet may begin with a six-question definition matching section (memorization), then have eight straightforward questions requiring students to apply a provided formula to a labeled diagram (procedure with connection), and end with one open-ended problem asking students to draw and label a shape, then create a problem for a friend (doing math). It is impossible to look at the activity sheet and label it with a single level of cognitive demand. Thus, because the level of cognitive demand can vary across a single resource, for this investigation, we calculated the resources' minimum level of cognitive demand, the most common level of cognitive demand (mode), and the maximum level of cognitive demand for every resource. For this made-up geometry activity sheet example, the resource would have a minimum level of demand of memorization, a mode level of demand of procedure with connection, and a maximum level of demand of doing mathematics.

THE TOP GRADES 3–5 RESOURCES

For this investigation, the first appearing 500 elementary school mathematics resources that were free and then the first appearing 500 elementary school mathematics

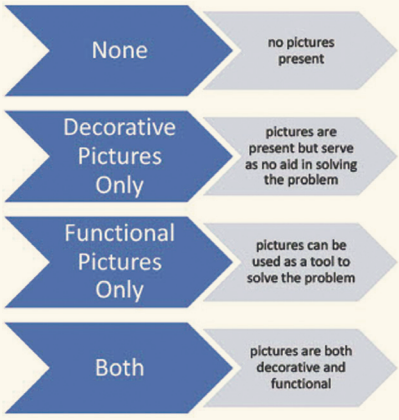
resources that cost less than $5.00 (referred to as "for sale") were downloaded. The $5.00 price limit on the "for-sale" resources was established on the basis of available funding for this investigation as well as Koehler et al.'s (2020) determination that 92% of TpT sales are for $5 or less. After removing any resources that did not

Table 1 Detailed Description and Examples of Resources Found on Teachers Pay Teachers

Cognitive Demand	Description	Example
Memorization	• Cannot be solved using procedure because a procedure does not exist or the time required to solve the problem is too short • Has no connection to concepts	
Procedure Without Connection	• Is algorithmic • Focuses on applying a procedure to produce a correct answer • Has no connection to concepts or meaning of procedures	
Procedure With Connection	• Makes connections among multiple representations (often including diagrams or manipulatives) • Focuses on procedures to help develop meaning	
Doing Mathematics	• Requires nonalgorithmic thinking • Explores mathematics concepts and connections • Demands self-monitoring • Has multiple solution paths • Requires explanation	

include mathematics tasks to be solved (e.g. posters, copies of manipulatives) and those that were not for Grades 3–5, there were 462 resources (174 free, 288 for sale) to be investigated. These were categorized for intended grade level, Common Core (CC) domain (National Governors Center for Best Practices & Council of Chief State School Officers, 2010), picture type (see Figure 2), and level of cognitive demand (see Table 1; for resources with different types of questions, a minimum, mode, and maximum cognitive demand was recorded). To clarify with an example, look back at Activity 2 in Figure 1, which was created by Miss Giraffe and is sold on TpT for $4.00. It is advertised for Grades 3–5, falls under the Numbers and Operations–Fractions domain, and contains both decorative (children holding dice) and functional pictures (a hundred grid). This entire activity was considered Procedures With Connections because of the connections among multiple fraction notations and representations. All 462 resources went through this process, with each resource categorized on the basis of intended grade(s), the cost, CC domain, picture type, and cognitive demand. Following categorization, the various categories were statistically analyzed against one another to determine the dispersion for each criteria. The chi-squared (Pearson, 1992) statistical method was used to determine if evidence existed that the results could have occurred by chance or if instead, evidence existed to suggest an unequal dispersion (this was determined with an established significance level of 99%). Main takeaways are described below.

Figure 2 Brändström's (2005) Categorization of Picture Type Adopted for This Investigation



WHAT WAS DISCOVERED

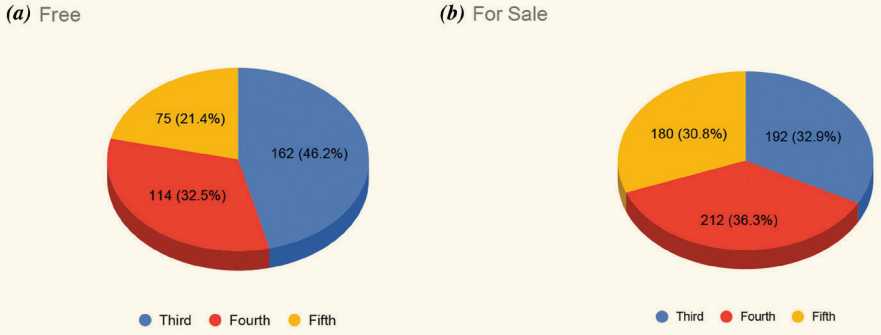
Free Versus For Sale by Grade Level

Grades 4–5 have fewer free resources (see Figure 3) than Grade 3. Thus, if you teach Grades 4 and 5, you will likely have to go deeper into a search to find free resources.

Free Versus For Sale by Cognitive Demand

Overall, free resources had a lower level of maximum cognitive demand than resources that were for sale (see Figure 4). For both free and paid resources, those considered Doing Mathematics are underrepresented (i.e., they do not account for 25%), but considerably more resources include at least one Doing Math task on the for-sale resources (2.3% of free vs. 10.8% of for sale). An implication is that relying

Figure 3 Comparing Free vs. For-Sale Resources at Associated Grade Levels 3–5



on free resources does not provide many resources that reach the highest levels of cognitive demand, so if you are searching for free resources, you will likely have to search longer to find some at the higher demands, or you may instead choose to purchase resources.

Free Versus For Sale by Picture Type

Regardless of price, the resource has a relatively equal chance of containing a functional picture (see Figure 5). However, resources that cost money are more likely to also include decorative elements. Thus, free resources tend to be less eye-catching. On the basis of Brändström's findings in 2005, we had expected to see an influx of decorative pictures for both free and for-sale resources, but in learning more about fees that teacherpreneurs pay associated with copyright for image use, this is less surprising. The implication is that if you want resources that have functional pictures, you should be able to find them both in the free and for-pay items on TpT, which is a positive aspect because functional pictures point students toward multiple representations.

Cognitive Demand by CC Domain

The majority of resources (50–75%) across all the CC domains are, on average, at the lower levels (red and blue) of cognitive demand (see Figure 6). There is not a balance of levels of demand, as O'Donnell (2009) recommended. Thus, when searching, you should not expect to easily find resources at the higher levels of cognitive demand.

Additionally, the spread of cognitive demand differs between mathematics topics based on the CC domain (see Figure 6). For example, more geometry resources are at the Memorization level (blue).

Figure 4 Comparing Free vs. For-Sale Resources and Their Maximum Level of Cognitive Demand

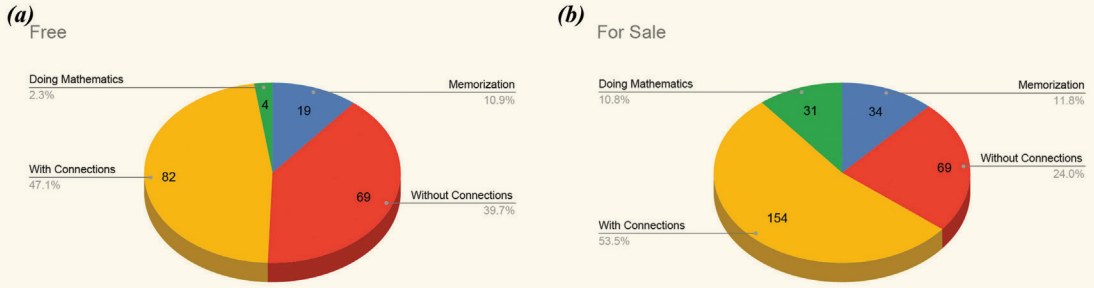
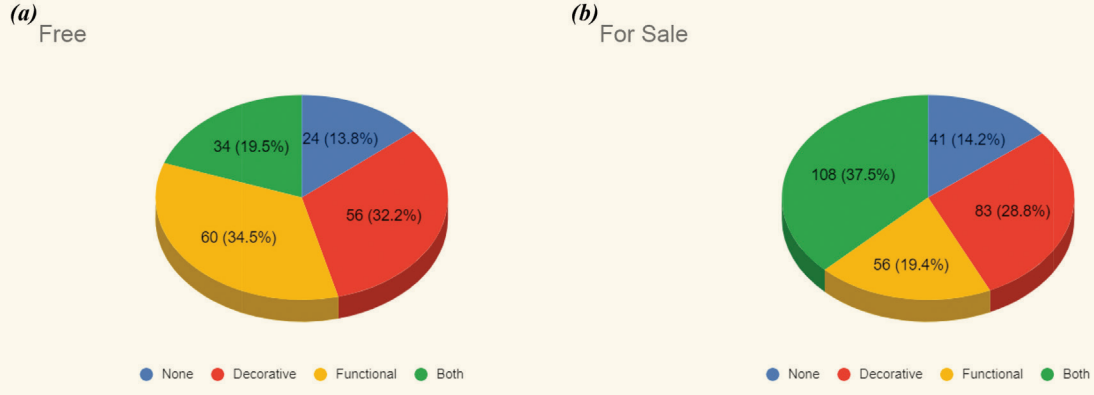


Figure 5 Comparing Free vs. For-Sale Resources and Their Associated Picture Types



Many geometry-based resources we downloaded included simple tasks like identifying the name of a shape, listing its attributes, or identifying formulas for area and perimeter. Tasks such as these are expected for early phases of geometric instruction that include visualization. However, we had hoped to see more resources that included the depth students need to interact with geometry more conceptually to prepare them for future years of mathematics learning. More encouragingly, Number and Operations–Fractions resources had the highest level of demand. These often contained visuals or manipulatives that aided the student in solving the problem. When searching for resources, be aware of these discrepancies and keep them in mind when searching for resources for various mathematics topics.

HIGH-DEMAND EXAMPLES

Despite the somewhat critical nature of this investigation, multiple resources were uncovered, often buried pages into the search, which display the kind of quality that we hope will eventually comprise these types of online curricular resource-sharing sites in the future. Consider the following two examples of high-demand resources that were part of the investigation and for which permission was obtained to share.

Figure 7 includes an example of a high-cognitive-demand geometry task card created by Teaching With a Mountain View. For this card, students can provide multiple answers and, more importantly, can find an argument for each of the triangles not belonging. Having multiple correct answers allows room for

Figure 7 Example of a High-Demand Geometry Task Card Created by Teaching With a Mountain View

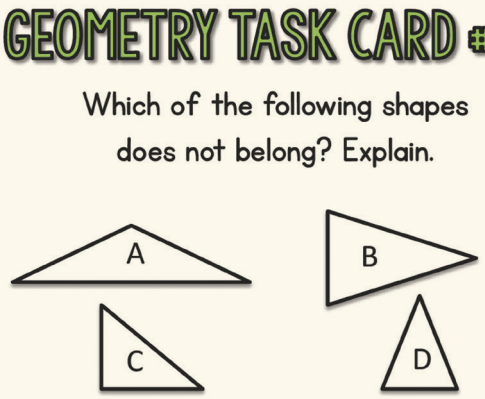
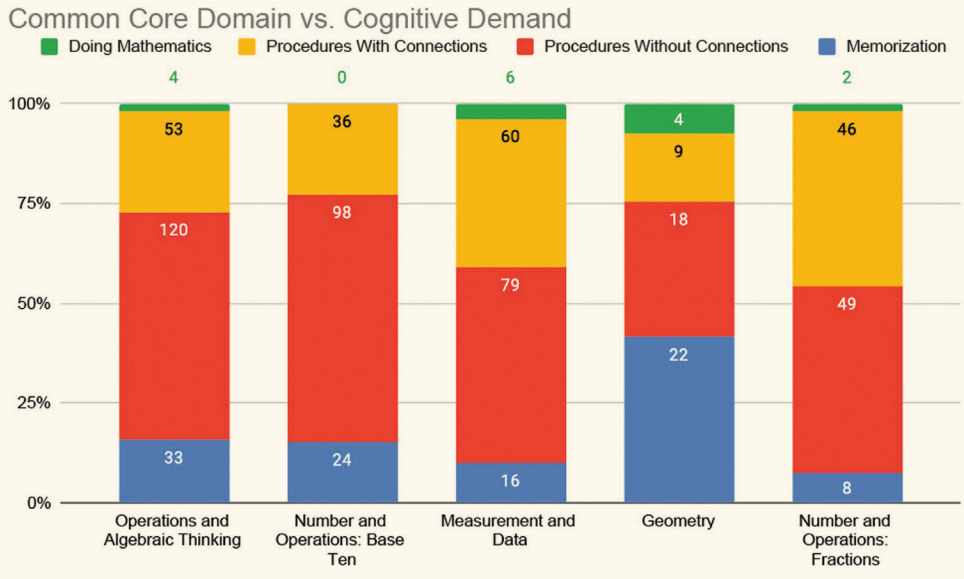


Figure 6 Comparing Mode Cognitive Demand Across CC Domains



students to discuss similarities and differences among the four triangles. The design of this resource allows students to explore the attributes of shapes far beyond just looking at a shape and identifying it. The card itself uses a font that contributes to the visual appeal, but the card has no unrelated, decorative pictures. The pictures of the triangles are needed to answer the question, and the question itself requires explanation.

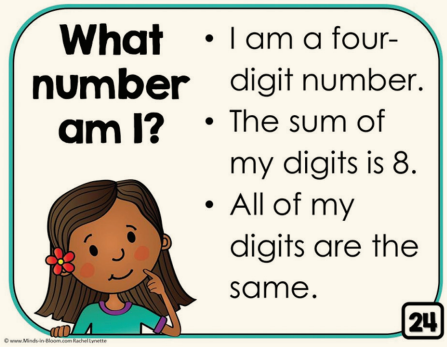
Figure 8 also includes a high-cognitive-demand task card created by Rachel Lynette. This Name That Number activity includes addition, place value, process of elimination, and logic problem solving. Students determine the number through trial and error and are able to monitor their own work by checking that it aligns with the criteria listed. This activity is part of a series of task cards with varying levels of cognitive demand. Despite the solely decorative picture on the example card seen in Figure 8, overall, the collection of cards is challenging for students and fosters self-accountability in students' work.

These two examples show that Grades 3–5 resources reaching the higher levels of cognitive demand are available on TpT and presumably on other resource-sharing sites as well, but you may have to spend additional time scrolling to find them.

IMPLICATIONS

As of 2022, TpT does not contain an equal dispersion of cognitively demanding mathematics resources across the different Common Core domains for students in Grades 3–5. Although we found many incredible resources, sometimes an activity sheet had only one high-demand question on it, with many more low-demand questions; other times, maximum high-demand resources were often buried deep within searches. The internet operates through invisible algorithms that seem to put the most often viewed or oldest created information at the forefront (Sawyer et al., 2020; Silver, 2021). Although these curricular resource-sharing sites do not share their search algorithms, because every resource we categorized had five stars, resources that are rated highly are clearly prioritized in search results. These resources are the first that appear, so these are likely the ones that are purchased and downloaded. Once downloaded, the website recognizes this and keeps them at the top of searches. Meanwhile, cognitively demanding, high-quality mathematics resources are potentially being created and submitted to resource-sharing sites but are not as easily found. Thus, we must look past the first resources we see. We have to look past the appearance, the number of downloads, and the five-star ratings and continue searching for more. We also have to be sure to look at all of the questions on a resource and look for a dispersion of cognitive demand. Keep scrolling! There may be resources that fill the gaps found through this investigation, but it is up to us as teacher consumers to find them because resource-sharing sites do not have an algorithm for cognitive demand or mathematical quality. And even when choosing resources online, we have the opportunity to adapt others' work to best fit the needs of students in our classrooms (e.g., Drake et al., 2015; Zawojewski, 1996).

Figure 8 Example of a High-Demand Numbers and Operations Task Card: What Number Am I? Created by Rachel Lynette



TEACHER VOICES

Three of us worked on this investigation prior to beginning our formal teaching career and are now practicing elementary teachers. Since we learned how to classify resources on the basis of their cognitive demand, we consider the cognitive demand of resources and try to ensure that over the course of a unit, we are engaging students across all four levels. Often this means adapting questions from resources to raise the level of demand, and sometimes it means choosing not to supplement with online resources. We now share our different experiences with searching for and implementing resources found online.

Teacher A: I also look for how well the activity connects to the standard that I am teaching. I will select a

resource if I feel that it reflects the standard best. I always pay attention to price. Free is always better, but I will sometimes pay for cheaper things (usually about $1). Then I ask myself, how will my students like this activity?

Teacher B: My district's former math curriculum was not aligned to the standards. As a result, I supplemented it with resources located online that I adapted for various levels of cognitive demand in order to best support all my students and their learning needs. Now that my curriculum is standards-aligned and I rarely need to supplement, I have found that using resources I analyzed from this investigation provides me with a starting point when creating differentiated lesson plans.

Teacher C: When I began teaching, I realized how truly helpful teacher resource-sharing sites can be. I also know how easy it can be to pick a resource quickly because of visual appeal or it being listed at the top of the search. But from this investigation, it is clear to me that having a proper mindset when navigating these sites is essential. By no means are we challenging these websites to put out flawless resources for teacher and student consumption. That being said, when I find a resource that I mostly like but the cognitive level of demand is not what my students need for a particular topic, I increase it by adding questions that require them to explain their thinking or connect their thinking to a pictorial model. I also search for sources on sites that have a peer-review process, such as NCTM's Illuminations (link online). As teachers, I believe we have to keep reminding ourselves to go the extra mile, and this often means adapting resources to fit the needs of our classroom.

FINAL THOUGHTS

From our research, we found that limitations to online resource supplementation include unequal dispersion across grade levels, mathematics content area, price, and level of cognitive demand. Despite the disparity, we believe it is important to remember that every resource we choose does not have to be absolutely perfect for it to be used in our classrooms. What is needed, however, is a variety of cognitive-demand resources that align to learning and performance goals. Using the TAG to choose activities in each demand level allows us to know that our students are developing conceptual understanding that helps them build the foundation they need for future mathematical content. As teachers and teacher educators who participated in this investigation, we believe in the importance of searching knowledgeably, with learning goals and student needs in mind, and of adapting what is found as needed. Rather than reinvent the wheel, we can be critical consumers of online resources.

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