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The Game of Teaching Resource Allocation

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ABSTRACT

In response to the increased prevalence of remote learning, and exhortation that educators adopt more experiential pedagogy, a methodology is presented to use a free, commercially available game to teach a variety of resource allocation problems in various disciplines. The use of games to provide experiential learning has been shown to increase student enjoyment and mastery of learning outcomes. The technique is appropriate for students at different levels from secondary school through graduate-level university instruction. The lack of cost to the student or university coupled with the ease of adaptability of the game makes the technique widely available to all instructors in both traditional classrooms and distance education settings.

INTRODUCTION

The purpose here is to present a technique for exploiting a free game available on smartphones. This technique will provide an innovative teaching method for a variety of social science topics requiring decisions on resource allocation applicable to management, finance, economics, education, project management, and budgeting, including personal budgeting. The method centers on the concept of applying experiential learning and edutainment to teach previously difficult concepts in a more appealing way that hopefully will engage students, especially those learning remotely. The exercise can easily be modified by including or omitting various details as described herein. These modifications allow the individual instructor to tailor the exercise to a variety of topics involving the allocation of limited resources and to be appropriate for students at all levels. The heart of the learning exercise is an analogy of elements in the game *Merge Defense 3D* and elements of the instructional environment. Students will be guided in the creation of a relatively sophisticated set of tools using only the game and Microsoft Excel.

The United Nations Principles of Responsible Management Education (PRME) has challenged educators to find ways to engage students, fostering understanding of the complicated traditions underlying contemporary conceptions of organizations and management. Using gaming simulation addresses two of the three aspirations of PRME, namely confronting the cognitional myth that knowing is like looking and moving beyond mere analysis to systems thinking (Kelley & Nahser 2014). Glen, Suciu & Daughn (2015) noted that business schools continue to neglect necessary exploratory skills embraced by design practitioners and deemed essential in complex and rapidly changing organizations. They stressed that this design thinking is an exploratory process involving iteration, visualization, experimentation and feedback. Modern business practice often includes decisions that incorporate messy, ill-structured problems, exposure to which may be missing from traditional instruction and is frustrating to students. This type of amorphous problem is addressed in the unpredictable elements and unstructured process inherent in the game presented here.

Evidence suggests that the use of games to aid in instruction of complex concepts increases student satisfaction and enhances mastery of learning objectives (Farrell, 2005; Okanlawon, et al, 2017). However, the efficacy and use of games as an instructional aid is limited by the availability of the game to the student and the effort of the instructor in finding games that appropriately fit learning objectives (Susi & Johannesson, 2007).

Anecdotal evidence suggests that the wholesale move to distance learning during the COVID-19 pandemic exacerbated the problem and had an overall detrimental effect on the learning outcomes of participants. Yet, remote learning continues to be the most cost-effective and inclusive method of delivery of education (Drane, Vernon & O'Shea, 2020). Educational institutions at all levels are necessarily turning more toward digital tools and advanced technology. Often access to these methods, and therefore student success is limited by the financial means and availability of technology of the institution and/or the student. Thus, access to free tools expands availability to a wider audience (Mucundanyi & Woodley, 2021). Smart phones are the most widely used and easily available access point to electronic tools and communication especially in developing countries (Alfawareh & Jusoh, 2017). Availability and lack of cost make the technique presented here particularly appealing.

THE GAME

Although the game is available free, courtesy of advertisements, the advertisements are innocuous for players of all ages and sensibilities. Most students find the gameplay enjoyable and, being accustomed to advertisements in games, they find the experience a pleasant way to learn. *Merge Defense 3D* is available without charge at the App Store for Apple, Google Play for Android, and at https://dapkforpc.com/ for Windows. It is suggested that the reader download the game and become familiar with it, keeping in mind applications to specific teaching topics appropriate to instruction in individual disciplines. After having played a few rounds, the reader should be able to relate to this brief game description and then the learning exercise that follows without difficulty. A potential state of the game on Turn 20 is reproduced in Figure 1 below.

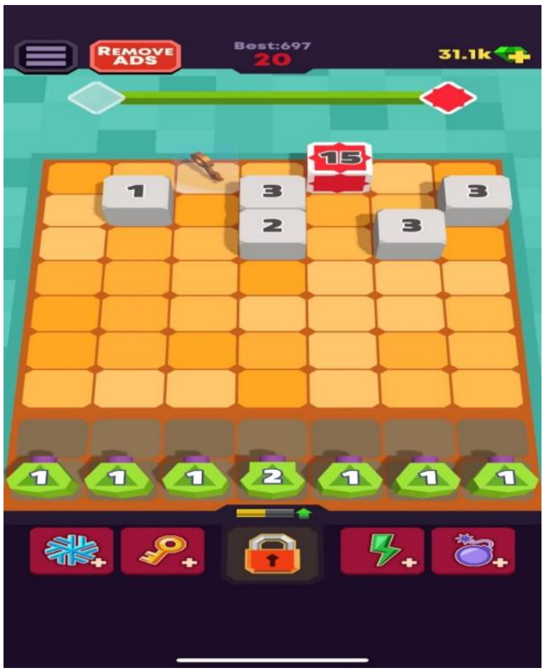

Figure 1: Potential State of Game, Turn 20

Across the top, one will find a green progress bar that indicates progress on each turn. It expands as it counts down toward turns on which red blocks with particularly large numbers will appear on the top row. Other than their color, these blocks are unremarkable relative to this example, which is appropriate for a mid-level undergraduate materials management class but might be given additional significance as the game is applied to other learning scenarios. The bar is fully extended in Figure 1, because the red block has just appeared in the game. Below the progress bar, the play area is divided into a seven-by-seven grid followed by a two-by-seven grid below that. These are referenced here as the upper and lower table, respectively. The columns of these tables are labeled one through seven left to right, analogous to the production lines in a manufacturing facility. In another application, they might represent progress toward other named goals. The rows of the upper table are numbered from T+1 to T+7 bottom to top. Elements, mainly blocks, appear each turn on Row T+7. In the manufacturing example outlined here, they represent the demand to be met. They could represent expenses accumulating in a budgeting example or any number of other variables in other examples. At each turn, the elements on the upper table are influenced by elements on the lower table, as described below, and then if they have not been eliminated, move down one row. Each turn is one unit of time. If a block (but not any other type of element) on the bottom row has not been eliminated before the end of that turn, the game is over. In this example it represents missing a production deadline. Again, in other examples it might represent other types of deadlines such as paying an invoice. Avoiding this is the overall goal of the game and one of the goals of the learning exercise.

Because *Merge 3D* was designed solely as a game and not as an educational exercise, not all elements of the game will be used as surrogates for an element in the instruction. Several things that exist in the game are ignored or minimized in the example presented here. Keys and gems are elements on the upper table. For this example, keys and gems might be thought of as one unit of demand, but they are not the blocks that are central to this production example, so the game does not end if they are not eliminated before reaching the bottom. Instead, they disappear and nothing else happens. Which elements of the game were stressed and the instructional element each represented would necessarily be dependent on the concept being illustrated.

The lower table is where all decisions are implemented. In this example, the focus is on the second row with the first row being less important. In other examples, this may not be the case. Each turn the player places, moves, or combines turrets on the lower table. In the current production example these turrets represent capacity. In other examples they could represent other resources. New resources can be placed into an empty cell at will or into an occupied cell, subject to rules regarding the placement of new resources where resources already exist. In cases when the new and existing resources have the same numerical indicator, resources are combined into a single unit. In this case, the number indicated on the resource is increased by one. If, however, a resource is placed where resources with a different resources level exists, the two resource sources exchange places. On each turn, after the player makes any decisions concerning the resource utilization, one or more paintballs are fired toward the elements in the upper table by the turrets. This represents progress toward fulfilment of the demand. The fulfillment of demand is indicated by elements on the upper table either disappearing, if the demand has been fully satisfied, or reduction of the numerical values in the case of partial fulfilment. After fulfillment, all remaining elements on the upper table move down one row.

In addition to representing one unit of resource demand, keys also represent the placement of new resources or the upgrade of existing resources. A fuller understanding of the effects of allocating resources amongst the seven areas of demand is the goal of the learning exercise.

The second progress bar, below the lower table, advances slightly each time a key is collected and counts toward the time when collecting the next key will yield more resources. New resources ready for deployment appear just below this smaller progress bar after a key is collected. The four buttons along the bottom are various tools the game provides to make play easier. Taken in total, these four buttons can be thought of as some way of increasing resources relative to demand. In a management environment, these increases would represent actions such as overtime or outsourcing. In a personal budget they might represent working additional hours or borrowing. In any case, the instructor is encouraged to play the game to a point well beyond the level of progress expected of the student and carefully consider what allocation issues each element of the game might represent.

Prior to introducing the game as a learning tool, the students should be asked to download the game and become familiar with it through play. During use of the game in instruction, it is helpful if, after discussing a section of the learning exercise, the students are asked to access class with *Merge Defense 3D* already on a turn you have assigned, and a spreadsheet complete up to a point you have assigned. In this example, the students start a new game using the following heuristic for several turns:

- Place new resources immediately as available.
- Do not place two sources of resource in the same column.
- Add or move resources to a column with a key.
- Do not remove resources from a column with a key.
- Add or move resources to the column with the greatest total demand once columns with keys have resources.
- Always remove from the column with the least total demand when reallocating resources.
- Give priority to the column with demand in the lowest row in the case of equal demand.

The suggestion to never place two sources of resource in the same column allows a “do nothing” option of moving resources from one row to the other in the same column. The heuristic above is given to the students as guidance, but they will often discover for themselves that exceptions may be warranted. The suggestion not to remove resources from a column with a key should be violated to prevent the recovery of multiple keys in the same turn. Although not stated above, it is generally a good idea to place resources in columns without resources before combining and upgrading resources. If there is excessive demand in one column, upgrading resources in that column before ensuring resources in every other column may represent the best option. This decision is both a personal choice and an opportunity to talk to your students about flexibility. Merging to create higher level resources represents a focus on higher total capacities, while avoiding this represents a focus on more flexibility in capacity.

CUMULATIVE DEMAND

Around turn 20 is the earliest time when the demand pattern on the upper board is such that non-trivial resource planning problems arise. The first step in creating a tool to prevent missed deadlines is the translation of the game into Microsoft Excel. Figure 2 represents the same data as Figure 1, now converted into an Excel file. All cell references described below assume the table is in cells A1:H9.

Throughout the exercise, students will transcribe data from the game into cells of this newly created table. The raw data will then be converted into a rather sophisticated set of resource planning tools described below. The next step after recreating a table like Figure 2, is the creation of a table representing the cumulative demand for each column and time-period. Cell references described below assume the table is in cells A11:H18.

20	C1	C2	C3	C4	C5	C6	C7
T+7			1		15		
T+6		1		3			3
T+5				2		3	
T+4							
T+3							
T+2							
T+1							
Turret	1	1	1	2	1	1	1

***Figure 2*:** Upper and Lower, Turn 20

In each column of the cumulative demand table, the value in T+1 is equal to the value in T+1 of the upper table. For example, cell B18 is “=B8”. The values in the other rows of the cumulative demand table are equal to their associated cell from the upper table plus the value of the cell directly below them in the cumulative demand table. For example, cell B17 is “=B7+B18”. Figure 3 represents the full cumulative demand table that is associated with the data in the previous figures.

Cum Dem	C1	C2	C3	C4	C5	C6	C7
T+7	0	1	1	5	15	3	3
T+6	0	1	0	5	0	3	3
T+5	0	0	0	2	0	3	0
T+4	0	0	0	0	0	0	0
T+3	0	0	0	0	0	0	0
T+2	0	0	0	0	0	0	0
T+1	0	0	0	0	0	0	0

Figure 3: Cumulative Demand, Turn 20

CUMULATIVE RESOURCE SUPPLY

The next step is the creation of the cumulative resource supply table. In each column of the cumulative resource supply table, the value in T+1 is equal to the resources in each column. Recall that the relationship between resource label and resource volume is non-linear. To address this, it is convenient to create a table which relates the label values of resource and the amount of resource it represents. Figure 4 represents such a table. Here, cell references assume the table is in cells J1:K11.

Level	Capacity
1	1
2	4
3	8
4	16
5	40
6	100
7	240
8	560
9	1300
10	3200

***Figure 4**:* Total Capacity

Now that the resource table has been created, it can be used to automatically translate resource labels to resource values and thus create a cumulative resource supply table. Cell references described below assume the table is in cells A20:H27. Of the Excel functions used in this exercise, the first that is likely to be unknown to many of your students is the “vlookup” function. It requires three arguments and allows for an additional optional argument. The first argument is the lookup value, the second is the table array, the third is the column index number, and the fourth optional argument is not used. Therefore, in each column of the cumulative supply table, the value in T+1 is equal to the vlookup function with the following arguments: the resource label for the column, the resource table, and “2” indicating that the resulting value comes from the second column of the described table. For example, cell B27 is “=VLOOKUP(B9,J2:K11,2)”. This will cause Excel to look for a value equal to the one in cell “B9” in the leftmost column of cells “J2:K11” and once found, return the value in column “2” of that row of that group of cells. The values in the other rows are equivalent to these values plus those directly below in the cumulative supply table. For example, cell B26 is “=VLOOKUP(B9,J2:K11,2)+B27”. Figure 5 represents the full cumulative supply table associated with the data in the previous figures.

Cum Sup	C1	C2	C3	C4	C5	C6	C7
T+7	7	7	7	28	7	7	7
T+6	6	6	6	24	6	6	6
T+5	5	5	5	20	5	5	5
T+4	4	4	4	16	4	4	4
T+3	3	3	3	12	3	3	3
T+2	2	2	2	8	2	2	2
T+1	1	1	1	4	1	1	1

Figure 5: Cumulative Supply, Turn 20

Although carrying the example farther might not be applicable to so wide a variety of resource allocation issues, the exercise was extended significantly for use in an advanced class to introduce more sophisticated topics. The materials management tools included: available to promise, aggregate planning, production scheduling, disaggregation and the master production schedule. Space limitations and a possible failure to be precisely applicable to general resource allocation issues preclude a full discussion of these more advanced topics, but the author would be happy to provide that information to interested parties.

SUMMARY

The illustration herein shows how a commercially available game provided free to the user can be adapted to provide an experiential learning exercise adaptable to many of the resource allocation problems encountered in business education. Through its use, the student practices a range of problem-solving skills underrepresented in traditional educational techniques.

As anticipated, student engagement was higher and student comments were favorably enhanced by use of the game. After using the above-described exercise, student mastery of related learning objectives improved noticeably. Students also expressed a preference for using Merge Defense 3D to traditional end-of-chapter materials or cases to practice the concepts. Students relayed that they enjoyed playing the game enough that it kept them interested in what they considered rather difficult and dry operations management topic.

Currently, no formal experimentation with control groups and test groups has been available to gather data on performance. All the evidence of the benefits of using this exercise are currently anecdotal. Addressing this shortcoming is an avenue for future research expected to be addressed.

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