Exploring a New Approach to Visual Asset Design

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Abstract: This paper will present a tool and a method to help game developers make decisions about creating visual assets such as game characters. It will also present results from a series of studies. The first study utilized this research tool to investigate middle school students' attitudes toward sixty game characters in the area of science, technology, engineering and mathematics (STEM) in commercial games. The second study used the most liked and disliked characters (by gender) determined by the first study in an educational game as science mentors. After presenting the effects of using these characters in motivation of students towards the game, the paper will conclude with research-based implications for educational game designers wanting to maximize motivation through the use of game characters in STEM-related educational games. Readers will also be informed about a method useful for developing visual game assets, and insight about creating characters for STEM educational games.

Introduction

Designing visual assets usually requires a great deal of intuition and/or experience. The creation process for characters' appearance in video games can be especially challenging. Game characters not only have to fit the character's personality within the narrative, but oftentimes must also look attractive to the target audience. This is even more important for game characters that are not customizable. In these cases, the visual presentation is quite literally a work of art that is presented to the players.

A distinctive design or style of appearance can imprint themselves on players' minds for life. Mario of countless Mario Brothers titles, Gordon Freeman of Half-Life, Lara Croft of Tomb Raider are all well-crafted characters whose image will be remembered by game players. Those characters have established their brands in the minds of gamers, marking their territory, and making them hard to mimic without copying. Looking back on the view of characters as art, this parallels art being associated with branding in other commercial areas (e.g. company logos or mascots).

Some guidelines for designers and artists exist about how to create game characters (i.e. Isbister, 2006). For example, stereotypes, attractive characters, or baby-faced characters may help to achieve the goals of personality. However, innovation is also necessary to establish interest towards a new game. During the design and development process, designers and artists may ask a focus group for their option about characters appearance before deciding which to use in the game. Those same people may benefit from tools that can help them to determine common characteristics among visuals for game characters, as well as to gain insight from users on those visuals.

Similarly, it is oftentimes difficult for researchers to understand a person's reasoning when they make certain decisions. Although methods like think aloud may aid researchers, people may have difficulty verbalizing the reasoning behind a certain choice, while they are making that choice (Wilson, Hodges & LaFleur, 1995). Tools that can help with understanding this process would be useful for researchers. This paper presents a digital tool and a method to facilitate people's thought process and help researchers to understand the reasoning for selecting certain items, in the case of this paper, visual assets, in groups.

In the next section, we will present this digital tool, digital pile sorter (DPS), and pile sorting methodology that the tool is based on. After presenting the tool, we will briefly talk about two different studies: The first study utilized DPS tool to determine middle school students' attitudes towards various STEM characters. The second study used these characters in an educational game. We will conclude with the implications of the results for game design including educational game design on the domain of STEM, as well as discussing possible other uses of the DPS.

Sorter Tool

The DPS tool was developed based on the pile sorting methodology (Weller & Romney, 1988). Pile sorting is a method used to understand people's perception and structure of a domain, through an observation of how they classify and group the items of that domain (Bernard, 2002). It is useful for investigating people's perceptions of the similarities and differences among items, and to discover variation in how people define domains. In a pile sort task, participants are asked to sort items into piles. These items can be anything that can be physically sorted into groups. The sorting task can be either a single sort or a successive sort.

Usually, in a single sort, the items to be sorted are randomized for each participant. For example, if these items are words on index cards, the researcher shuffles the cards. Participants are then asked to make groups with the cards in terms of similarity so that most like terms are in the same pile and unlike terms are not. Participants can make as many piles as they want. After the piles have been arranged the participant is asked why items were sorted as they were.

In the successive version, participants are asked to make a certain number of piles, usually two, with the items they are given. Participants are usually asked to group the items based on their similarity, without reference to a specific criteria. The subject decides on what criteria are most salient and determine similarity. Participants are then asked to subdivide the initial piles. The continual process of subdividing pile is repeated until it can no longer occur. This method enables the creation of a taxonomic tree for individuals, a group, or both. The structures produced by individuals can be compared.

The current sorter tool is built using Adobe Flash. The tool has multiple layers researchers or game developers can use to understand peoples' thought processes and attitudes. It allows sorting any number of image files into groups, using successive pile sorting mechanics (Boster, 1986). At the very basic level, researchers can upload image files, which may include pictures and/or words, and ask people to sort them into a certain number of groups based on similarity or based on a prompt in which the researcher is interested. Through iterated pile sorting, people can sort the images into several subgroups. In each level of sorting, researchers can insert multiple questions in the interface to facilitate users' thought processes or to probe their attitudes towards the images in the group (see Figure 2). Participants can zoom in an image to examine it closely. They can also move images between the groups. All of these processes, including the movement of images are time stamped, and recorded in a database for the researcher.

The DPS has been used in three studies so far. We will briefly go over one of those studies in the next section. In one of these studies, Hotaling, Lowes, Stolkim, & Lin (2012) used the DPS to assess middle school students' understanding of sensors. DPS asked students to sort eighteen cards that showed items with captions. Another study was designed to assess the high schoolers' understanding of who engineers are, and what they do. This was in an underwater robotics program that aimed to teach science and engineering concepts (Lowes & Tirthali, 2011). In this study, participants were shown pictures depicting people at work, and then sorted the pictures into one of 3 groups: engineers, not engineers or not sure. These two studies were constrained sorting activities. The last study that we will explain in more detail in the next section used successive pile sorting.

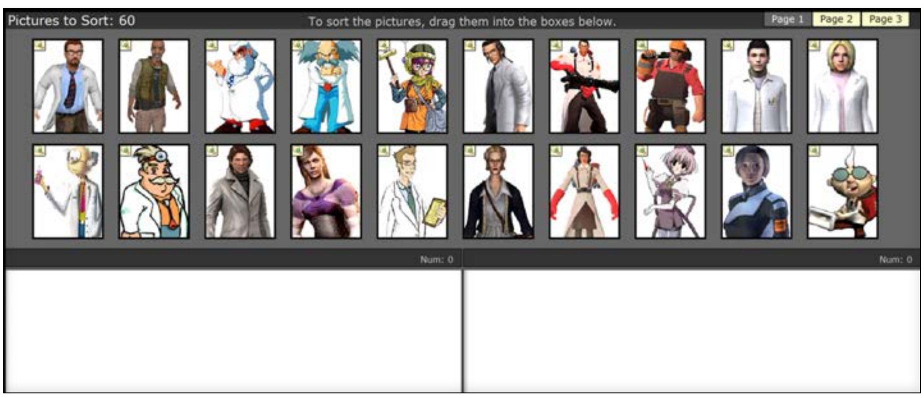

Figure 1: **A snapshot from Digital Pile Sorter as used in Study 1.**

Study 1: Determining What Characters to Use for Science Technology Engineering and Mathematics (STEM) Games

During middle school, students' attitudes toward science, technology, engineering and mathematics (STEM) tend to deteriorate, and continue declining throughout high school (George, 2000; Kotte, 1992). Reasons include students' perception of STEM being difficult and irrelevant (Jones et al., 2000), and scientists being perceived as isolated from the general public (Long & Steinke, 1996).

Social learning theory posits that children can learn cultural patterns of behavior through repeated observations of symbolic models depicted in media (Bandura, 1969). Media images of science influence public attitudes toward science and scientists (NSB, 2006). For many children, videogames are the media with which they spend the most time (Ito et al., 2009; Pew, 2008). Today's children spend much time playing, and there are strong indications that children learn from playing video games (Gee, 2009; Squire, 2008). Attitudes toward STEM can possibly be changed with well-designed game characters, with whom children would identify. Accurate representations of STEM in video games might also be helpful. This study's goal was to establish patterns of character design that may lead to these desired outcomes.

This study had three stages: 1) Identifying and classifying STEM characters in videogames; 2) Finding patterns among the characters that students like and dislike; 3) Investigating affective and cognitive effects of these characters on middle school students when integrated in educational games.

Utilizing the DPS tool, we explored possible patterns in students' perceptions about various aspects of characters in video games. These included perceived trustworthiness of characters as mentors, their intelligence, helpfulness and likability. We identified 317 STEM characters, taken from educational and entertainment video games: 245 male, 72 female. We randomly selected 60 humanoid looking characters among these STEM characters for use in this study with 35 sixth-grade students in New York City. Using the DPS tool, students first divided these characters into two categories based on the type of career they thought the characters represented, and labeled each category. To do that, students dragged the images from upper part to the category they chose. If they were not satisfied with the choice, they would drag it back to the upper section or to the other category box. After they finished sorting all 60 images into groups, they were asked their opinion about the characters in groups. To do so, students were presented with their categories one at a time and asked to make 3 subgroups: characters they liked most, least and weren't sure about. Lastly, they answered ten main questions (e.g., how much would you trust these characters to teach you in a game? On a scale of 1 to 10, how sociable do you think these characters are?) about each group of characters which they expressed like or dislike.

Findings revealed a mismatch between the characters identified as representing STEM careers and the characters students liked. Although all characters had STEM careers in games they came from, only 22 students placed them into a STEM category. Some of the labels for STEM category were doctors, nurses and scientists. Non-STEM labels included heroes, teachers and fighters.

Mirroring previous findings on how students perceive scientists (Barman, 1996), characters perceived as most likely to be in a STEM career were males with lab coats, facial hair and eye glasses. However, students disliked those characters. Four of the top five most liked characters by all the students were females. Moreover, students reported that they would trust the game characters they liked as mentors ($t = 3.264$; $p < 0.005$) and would want to play games that included those characters ($t = 2.02$; $p < 0.05$). This was opposed to those that were presented as prototypical STEM characters, older man with glasses and lab coats, but were not liked. Compared to the characters they did not like, participants rated characters they liked as more helpful, intelligent, heroic, strong, and sociable. This shows clear differences in students' perceptions about different game characters when they like them versus when they don't like them.

We also looked at gender differences in attitudes towards characters in different subgroups participants created. We found that males and females highlighted different characteristics for the characters in the STEM category. Male students think characters they sorted in the STEM category are more intelligent than what females think about the characters in their STEM group ($p < 0.05$, $t = 2.623$). Also, female students think players who play games with these characters more creative than what males think ($p < 0.05$, $t = 2.025$). The top three most liked characters by males and females are young and attractive images. Male participants especially disliked the stereotypical scientist images, most commonly used in educational games. The next logical step is to find out whether there are any differences in student motivation and learning in an educational video game when using characters students liked versus characters they did not like as determined in this study.

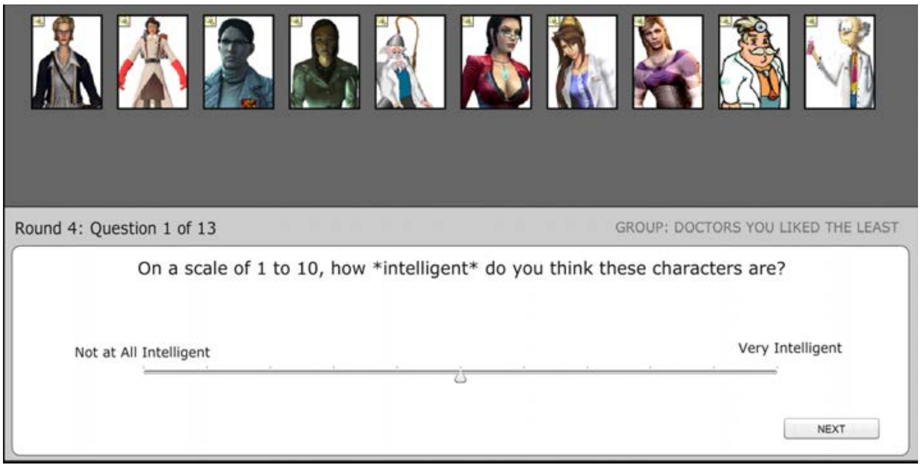

Figure 2: **Answering questions after sorting characters.**

Study 2: Using Characters as mentors in an educational game

The three most liked and disliked characters for males and females (for a total of 12 images) were determined (see Figure 3) as described in the previous section. These characters were used in a follow up study with an educational mathematics game called *Noobs vs. Leets: the Battle of Angles and Lines*. This game was developed by researchers at the Games for Learning Institute and was previously shown to be an effective educational intervention (Plass et al., 2011). The game has six chapters with each chapter introducing the player to a new concept about angles.

This study investigated the effect of choice (in this case choosing mentors) and the effect of varying feedback given by the mentor, with one hundred fifty-four sixth grade students (f = 74, m = 80) in a New York City school different than the one used in first study. In the beginning of the game, participants in the choice condition were given the option of choosing a single mentor out of six scientist characters. Players were told that this non-player character would give them feedback in the game. Females chose among the six characters that were most liked or disliked by female participants in the previous study. Males received their options in same way. In the No-Choice condition, players were auto-assigned one of the characters from the six that were made available to the choice condition. The assigned characters were distributed in the No-Choice group such that the participants in both groups had the characters in the same proportion [they were actually assigned with probability. There was an 0.8 of chance that students would be assigned to the same character] We will not look at the effects of choice or feedback in this paper. Rather, we will examine how students who had mentors that were liked in the previous study did in terms of achievement and motivation, compared to those who had mentors that were not liked.

We found a gender match between participants and the characters they chose. Specifically, female participants selected female characters as their mentors, and male participants selected male characters as their mentors (See Table 1).

		Character Gender		Total
		Female	Male	
Participant	Female	31	4	35
Gender	Male	1	40	41
Total		32	44	76

Table 1: **Participant – character gender match when choosing mentors.**

In the game, players filled out a set of motivation questions (e.g., how much fun was this chapter for you?, how much do you want to continue?) after every chapter. They also took paper based pre and post-tests to assess their knowledge of the topics covered in the game. We categorized the participants into two groups based on those who had one of the “liked” characters (Group 1, n = 94) and one of the “disliked” (Group 2, n = 60) characters. We found these groups not only showed motivational differences towards the game but also achievement differences in the game. In terms of achievement, Group 1 completed significantly more levels in the game then Group 2 did ($p < 0.0001$; $t = 4.00$). Group 1 also indicated more desire to continue playing the game than Group 2 did, both after the first chapter ($p < 0.05$; $t = 1.996$) and the second chapter ($p < 0.05$; $t = 1.996$) of game-play. Although Group 1 still rated their motivation to continue higher than the Group 2, statistically significant differences disappeared after the second chapter. Group 1 also reported that the game was significantly more fun than Group2 ($p < 0.05$; $t = 2.154$) after the first chapter. Although students reported mentors in Group 1 as being more helpful than the ones in Group 2, this did not reach statistical significance.

We also investigated achievement outside of the game. A paired samples t-test was used to examine the differences in gain from pre to post test in Group 1 and Group 2. Both groups had gains but only Group 1 had a statistically significant gain ($p < 0.001$; $t = 3.345$). Group 1’s higher gain in test scores might be also caused by their game achievement. The more levels students completed in the game the more practiced they became with the types of questions and concepts.

When we applied Chi-square test to examine the relationship between gender and groups, there was significance (see Table 2 for the number of participants in groups). X^2 (2, N =154) = 21.96, $p < 0.001$.

		Liked (Group 1)	Disliked (Group 2)	Total
Participant Gender	Female	31	43	74
	Male	63	17	80
Total		94	60	154

***Table 2:* Participant gender – character type**

As a follow-up, we investigated the differences in game achievement between Group 1 and Group 2 for each gender. For males, we found that the difference approached, but did not reach, significance ($p = 0.072$). Male students in Group 1 completed 30.02 levels on average compared to 26.29 levels in Group 2. One possible reason for this lack of significance is the low number of male students in Group 2. On the other hand, when we investigated differences between Group 1 and Group 2 for female students, we found significant differences in game achievement ($p < 0.005$; $t = 2.893$), with Group 1 outperforming Group 2.

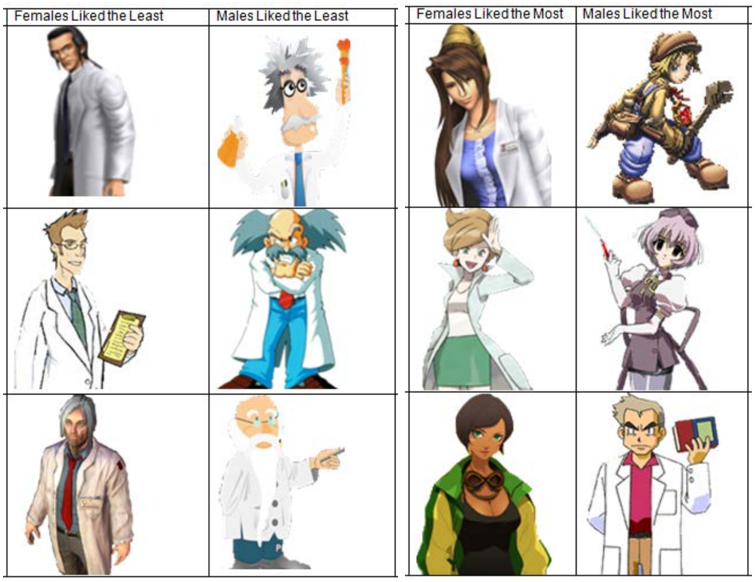

***Figure 3:* Most liked and disliked characters by males and females.**

Discussions and Conclusions

“Knowing your audience” is one of the key principles in design. Any tool that can help to understand preferences of a target audience is invaluable. This paper presented a research-based tool, DPS, that is based on the pile sorting method. It also presented snapshots about authors’ experiences with that tool. It also summarized a study that aimed to find out patterns for STEM characters that are liked and disliked by middle school students. This study revealed that the images taken from many educational STEM games fell into the scientist stereotype, older men with glasses, lab coat and facial hair, which were some of the least liked images by the participants. On the other hand, younger looking, attractive female character images were some of the most liked ones among sixty images. Students also rated these characters they liked as more trustworthy, helpful and intelligent. These results imply that these characters may be more motivating for students than the ones that were not liked. The results also bring several questions into consideration:

- Is it possible to come up with design characteristics for STEM characters to be used in educational games in order to motivate students to do better in these games and learn more with these games?
- Are there any age differences for character image preferences (as the target demographic for this study was six grade students)?

This paper also presented a follow up study that was designed to use some of these characters in educational games and test their potential effect on player motivation and achievement. Specifically, the second study tested the effectiveness of using the most liked and disliked characters (by gender) that were determined in the first study. This study showed that when given the chance, players in fact chose the liked characters that were identified by using the DPS tool. Motivational power of playing an educational game with STEM characters that players find intelligent, trustworthy and likable was quite apparent in the beginning levels of the game. Most importantly, the effect of these characters on players’ gain from pre to post test scores demands further research in this area. This study used the character images as mentors who provided feedback to players when they made a mistake. In that sense, students might have paid more attention to the liked characters, therefore, learned more. However, if we modify the role of these characters in the game (for example, instead of mentors they may be player avatars) their effect may change.

We believe that the sorter tool can be used for multiple purposes both in research and design. This would in turn eliminate unnecessary choices and reduce production costs for games. Moreover, the motivational and achievement differences when using different characters as mentors in the game are worth noting. Visual assets such as character appearance are factors that can affect players’ motivation towards the game, especially in the beginning. Educational game designers should keep that in mind given the importance of the “first impressions” when playing a new game. This likely to be especially applicable to educational video games that tend to be viewed less enthusiastically compared to popular entertainment games. In this vein, tools like the DPS can help designers during the design process in a similar way that was used in studies described in this paper.

Both studies reported in this paper have limitations. Although the number of participants was sufficient for statistical analysis, we do need further studies with students of varying demographics to confirm our findings. Luckily, this will be possible if other researchers or educators want to use the DPS tool with their students. The tool will be online and connected to a database to be used by public.

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Acknowledgement

This work was funded in part by Microsoft Research through the Games for Learning Institute. The content and opinions herein are the author's and may not reflect the views of Microsoft Research, nor does mention of trade names, products, or organizations imply endorsement.