

Using Edutainment to Facilitate Mathematical Thinking and Learning: An Exploratory Study

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The focus of the study is to ascertain levels of student creative-critical mathematical thinking and problem solving when the element of edutainment is introduced as a pedagogical tool. As in-class activities, seven participants viewed three randomly selected episodes of Numb3rs, completed associated activities/assignments, and participated in evaluating their learning experiences based on the episodes and associated activities/assignments. Two artifacts, video and student work, were used to determine levels of critical-creative thinking after completing edutainment-related mathematics activities. The results indicated that utilizing Numb3rs as a teaching and learning tool generally facilitated movement of students' thought processes to levels of critical-creative thinkers, increased engagement and promoted transition from fixed mindsets to growth mindsets. Intrinsic and extrinsic variables which may have contributed to ratings and student learning were included in the discussion.

Key Words: *Edutainment, critical-creative, growth mindsets, mathematical thinking, student learning.*

Edutainment combines educational content into an entertainment context facilitating learning and entertainment simultaneously (Singhal & Rogers, 2002). Finding pedagogical approaches, in a technologically driven culture, that cultivate critical-creative thinking is a challenge for mathematics educators. Traditional mathematical problem solving has focused on correct solutions utilizing appropriate algorithms, formulas, and traditional one-way approaches to problem solving. Although not always emphasized in mathematics classrooms, critical and creative thinking are essential skills needed in mathematics learning and discovery. While there is a lack of accepted delineation between characteristics of critical and creative thinking, the following definitions of critical thinking and creative thinking are appropriate for the purpose of this study:

- Critical thinking is the art of analyzing and evaluating (Paul & Elder, 2010).

- Creative mathematical thinking combines logical and divergent thinking based in problem solving approaches and solutions that are unique (Siswono, 2011).

Critical and creative thinking are both essential to *doing* math. Yet both are relatively unexplored areas with our young student mathematicians (Oldridge, 2015). Critical and creative thinking, for purposes of this study and within the edutainment framework, are perceived as interdependent and thus are referred to as *critical-creative thinking* (Figure 1).

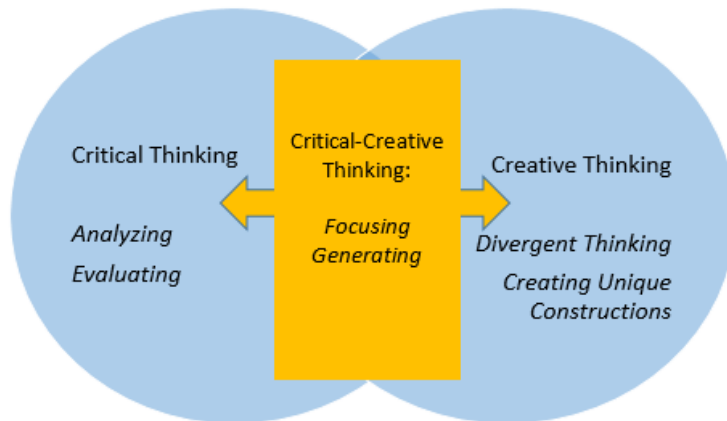


Figure 1. *Critical-creative thinking interdependence.*

Edutainment, a non-traditional approach, has proven to help foster other 21st century skills, such as critical-creative thinking (Zorica, 2014). Movement in mathematics education from a technical teaching disposition to a disposition of engineering learning can contribute to an environment conducive to critical-creative thinking (Tchoshanov, 2013; Lynch-Arroyo, 2013). Additionally, edutainment addresses the position statement of The National Council of Teachers of Mathematics (NCTM, July 2015), advocating integration of emerging technology within a focus on mathematics learning goals.

The intent of this exploratory study was to evaluate secondary pre-service mathematics teachers' (PSMTs') levels of critical-creative thinking using an edutainment component. Mathematical activities and assignments generated in connection with three random episodes of *Numb3rs*, a prime time American mathematically-based television series (2005-2010), were used as the pedagogical tools and strategies. Texas Instruments and NCTM supported the integration of the television series and the accompanying assignments (prepared by Cornell Department of Mathematics). This exploratory study sought to ascertain if the integration of edutainment (such as a mathematically-based television series, *Numb3rs*) facilitated student learning

and encouraged critical-creative thinking, as well as, what extraneous factors contributed to movement between *fixed and growth mindsets* (Dweck, 2008).

Theoretical Framework

Critical-Creative Thinking

Educational reform emphasis on equity relationships between teachers and students, facilitated with the introduction of pedagogical approaches such as ‘active’ and student-centered learning, requires new forms of teaching approaches to foster critical-creative thinking and meet the needs of diverse learners (Zorica, 2014). Prior to integration of a new pedagogical approach in classrooms, it is important to understand the potential of new pedagogies in relation to diversification of learning. The authors envisioned that utilizing edutainment as a framework to support evaluation of critical-creative thinking in mathematical problem-solving would present opportunities for observation of student thinking styles as applicable to the needs of 21st century learners. The television series, *Numb3rs*, was the edutainment tool/strategy used in this study as a springboard to encourage mathematical problem solving tasks that encouraged varied levels of thinking styles.

Fixed and Growth Mindsets

Prior to evaluation of thinking styles, it was important to operationally define characteristics of critical-creative thinking. Dweck (2008) posits two mindsets - fixed and growth; “People in a growth mindset don’t just *seek* challenge, they thrive on it” (p. 21). Based on her descriptions of both mindsets, the authors determined that critical-creative thinking predictably occurred in the realm of a growth mindset. Therefore, it was hypothesized that when PSMTs are faced with ‘*real-world*’ scenarios (albeit fictionally developed) through a mathematically-based television series, such as *Numb3rs*, critical-creative thinking would be evident for those PSMTs who possess a growth mindset in terms of mathematical problem solving. Levels developed by Siswono (2011), coupled with descriptions of characteristics from Anderson and Krathwohl’s (2001) Bloom’s Revised Taxonomy, were the most appropriate to evaluate critical-creative thinking (Figure 2).

Positive Deviance

A positive deviance perspective recognizes the idea “there are certain individuals or groups whose uncommon behaviors and strategies enable them to find better solutions to problems than their peers, while having access to the same resources” (Singhal, 2013, p. 5) or characteristic of the concept of growth mindset put forth by Dweck (2008). The identification of novel approaches to teaching and learning can be replicated or transferred to other settings through directed study and analysis. Singhal (2013) further posited that a positive deviance approach “enables communities to self-discover the

positively deviant behaviors amidst them, and then ... amplify them” (p. 6). Integration of this perspective encourages critical-creative thinking in mathematics classrooms, while contributing to identification of tools and strategies will engage diverse students in content that is critical to their preparation for the future.

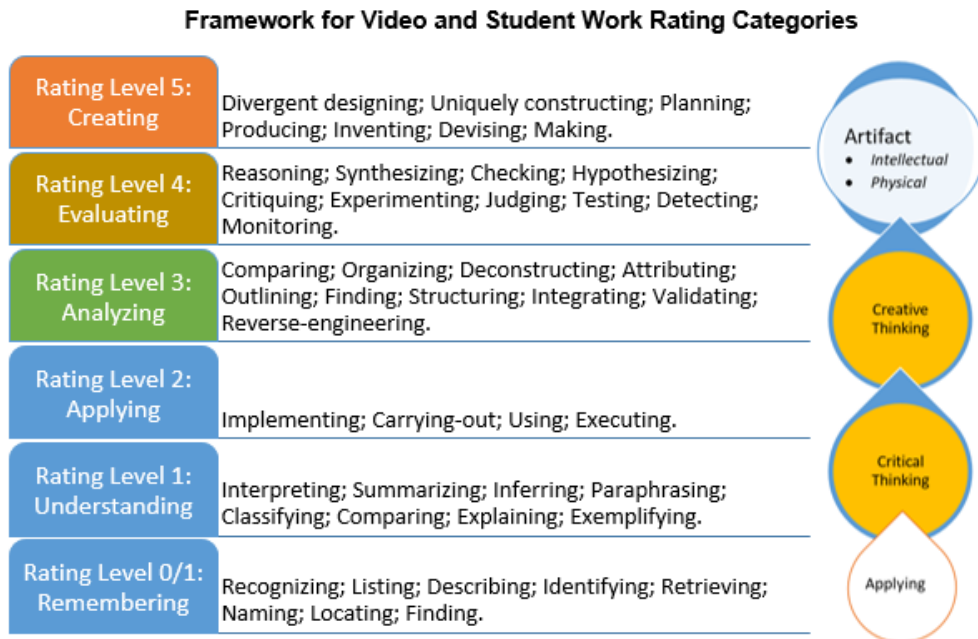


Figure 2. Framework for video and student work rating categories.

Within the components of the theoretical framework, the exploratory study of edutainment as a tool to facilitate mathematical thinking and learning at the critical-creative level was embarked upon. The guiding research questions were:

- 1) How does embedding an edutainment learning tool and strategy [Numb3rs] influence PSMTs thought process and transition to a critical-creative thinker?
- 2) How does edutainment affect student engagement in problem-solving and help PSMTs transition from fixed mindsets to growth mindsets?

As an exploratory study, it was not the intent to identify cause-effect relationships between edutainment and critical-creative mathematical thinking. Rather the research focus was to identify the impact of integration of edutainment tools and strategies as contributors to critical-creative mathematical thinking.

Method

Participants

The participants were seven preservice mathematics teachers [referred to as PSMT1, PSMT2, PSMT3, PSMT4, PSMT5, PSMT6, and PSMT7]. These PSMTs were pursuing their undergraduate mathematics degrees with secondary teaching minors and were enrolled in Teaching Mathematics in Secondary School in the Spring 2016 semester. Three of the PSMT participants were female between the ages of 18 and 23, three were male between the ages of 18 and 23, and one was male between age 23 and 28.

Procedures and Measures

In this study the following procedures were employed: Participants viewed (in-class) three randomly selected episodes from *Numb3rs*. These episodes were *Episode #214: Harvest*, *Episode #406: In-Security* and *Episode #506: Magic*. It is important to note that none of these participants had viewed this television series previously, nor had prior knowledge of the series. Participants completed three episodes associated activities and assignments (in-class student work with videotaping), three evaluations of the episodes, and associated activities and assignments. Activities and assignments were modified from the original Cornell University prepared assignments to establish a link to specific scenes in the episodes, provide differing levels of mathematical background information, and present a specific activity to complete. There was little or no instructor input on episode or activity content. During collaboration, the instructor did pose guiding questions as needed to facilitate activity focus. As indicated by the nature of the activity, hands-on materials and calculators were provided to the participants.

Measures included ratings of critical-creative thinking rooted in descriptors of Bloom's Revised Taxonomy, as well as, Siswono's (2011) descriptors of levels of creative thinking (see Figure 1). Zorica (2014) asserted "... the impact of video and multimedia technologies in educational outcomes is a field of ongoing research..." (p. 4091), while identifying three technological targets of educational impact for learners: (1) relating to the visual content; (2) engaging with content; and (3) transference of knowledge based in the video content. These categorical descriptors contributed to the rating framework as the basis of video analysis of each episode and related activities. Ratings took into consideration an overall collaborative approach[es] that reflected levels of critical-creative thinking. To confirm ratings and contribute to inter-rater reliability, the *Delphi Method of Consensus* was utilized, based on two rating iterations.

The Delphi method was developed by Dalkey and Helmer in the 1950s and was used predominantly at the Rand Corporation (Hsu & Sandford, 2007). "The Delphi method is an iterative process used to

collect and distill the judgments of experts...” (Skulmoski, Hartman, & Krahn, 2007, p.2) and provided for multiple iterations, controlled feedback, and considerations of ratings within the context of multiple raters (Lynch-Arroyo, 2013, p.102).

In iteration one, each rater independently reviewed and rated videos and student work samples utilizing the framework for video and student work criteria (Table 1 and Figure 3). In iteration two, raters deliberated upon evidence of individual ratings for each rating component with discussion of variations; through this discussion, rating consensus was achieved.

Results

Student Work and Video Analysis

Two artifacts – video (intellectual) and student work (physical) were used to examine students’ levels of critical-creative thinking when completing edutainment-related mathematics activities. All activities were rooted in scenes from the episodes utilizing similar mathematical thinking demonstrated in the segments. The videos were analyzed by identifying attributes of critical-creative thinking that occurred when students were collaborating (discussing, asking questions and problem solving) during completion of three episode-associated activities and assignments. Similarly, the student work was analyzed by identifying the correctness of the answers and by checking for attributes of critical-creative thinking in solving episode-associated assignments, with greater emphasis on characteristics of fixed and/or growth mindsets. The results from the ratings analysis of both sources of data are shown in Table 1 and Figure 3.

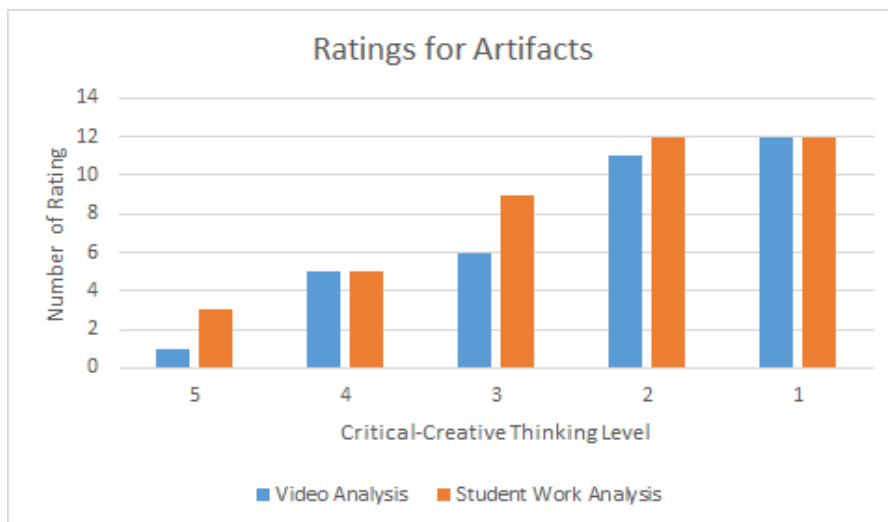


Figure 3. Comparisons of ratings for video and student work.

Table 1
Results from the Ratings Analyses

Assignment Ratings: Critical-Creative Thinking	Video Analysis					Student Work Analysis				
	5	4	3	2	1	5	4	3	2	1
Episode 214: Harvest										
Isoperimetric Inequality: Surface Tension		✓	✓	✓	✓		✓	✓	✓	✓
Planar Shapes		✓	✓	✓	✓		✓	✓	✓	✓
Stable Marriage Problem: Combinatorics				✓	✓		✓	✓	✓	✓
SAS Theorem		✓	✓	✓	✓					✓
Episode 406: In-Security										
Classification & Regression Tree: [CART Analysis]					✓	✓	✓	✓	✓	✓
Figure Ground Illusions Problem					✓	✓			✓	✓
Steganography					✓	✓	✓	✓	✓	✓
Polyhedron	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Episode 506: Magic										
Volume of Cylinders				✓	✓					✓
Hydraulic Press: Force/Distance				✓	✓					✓
Blood Spatter Trigonometry					✓				✓	✓
Pattern Analysis		✓	✓	✓	✓		✓	✓	✓	✓

Cross-analysis of video and student work ratings indicated similar critical-creative levels of rating results. That is to say, if evidence of critical-creative thinking presented in video analysis, corresponding evidence presented in student work; there were not obvious disconnects in collaboration participation and individual student work completed. In review of individual participant work, episode-specific activity comparative analyses follow.

In Episode #214: Harvest, students completed an Isoperimetric Inequality/Surface Tension activity and assignment; students were provided with connections to the episode and specific questions to respond to after completing the actual experimentation. Activity 1 levels of engagement, collaborative discussion, and unique approaches to problem solving were analyzed. The evidence from both the video analysis and PSMTs' work analyses indicated PSMTs were testing and hypothesizing their answers (Level 4 rating): evaluating or critical thinking.

In Activity 2 of the Isoperimetric Inequality assignment, planar shapes, there were many differing responses that arose from collaboration. PSMT3 specifically identified a collaborative approach in her response, "We had assumed that in a plane with area A, then there is a 'C' shape that has the same area and minimal perimeter. Therefore, if the shapes have the same area

then ‘C’ would be the shortest perimeter”. PSMT2 stated, “Considering shape ‘C’ is the whole area, then yes the other shapes within that shape will have smaller area. If we consider that shape C is a shape within a small perimeter, then it would also have the smallest area. $P = 36$ $A = 50$ ”. PSMT4 responded with “Both statements are true and equivalent because the two shapes together will always make the larger area”. Lastly, PSMT5 reflected, “Yes, b/c depending on how the shape is split up. If split first in half, ‘C’ has the largest area than the halves. This is all true depending on how the shape is split. If ‘C’ has the shortest perimeter of the 2 shapes, the 2 other shapes have the same area.”

The process of collaboratively making an assumption led to hypothesizing and testing in problem-solving. However, the uniqueness of individual learning was not compromised in collaborative approaches to problem solving, but rather enhanced by the nature of the collaboration. As an indicator of a growth mindset, collaboration appeared to enhance individual critical-creative thinking and the edutainment tool anchored learning to an example in the episode, giving PSMTs a point of reference to facilitate understanding of the problem posed.

The stable marriage problem from the Harvest episode was most closely related and anchored to the episode, however, critical-creative thinking was not present as evidenced in PSMT1's student work:

1. Use this algorithm to determine marriages for the above tables.

Man 3	_____	Woman 1
Man 2	_____	Woman 3
Man 1	_____	Woman 2

2. Show that this algorithm results in stable marriages.

1st Pick:

M_1	_____	W_1
M_2	\	W_2
M_3	/	W_3

M_1 married W_3	M_1	\	W_1
M_2 married W_2	M_2	\	W_2
M_3 married W_1	M_3	/	W_3

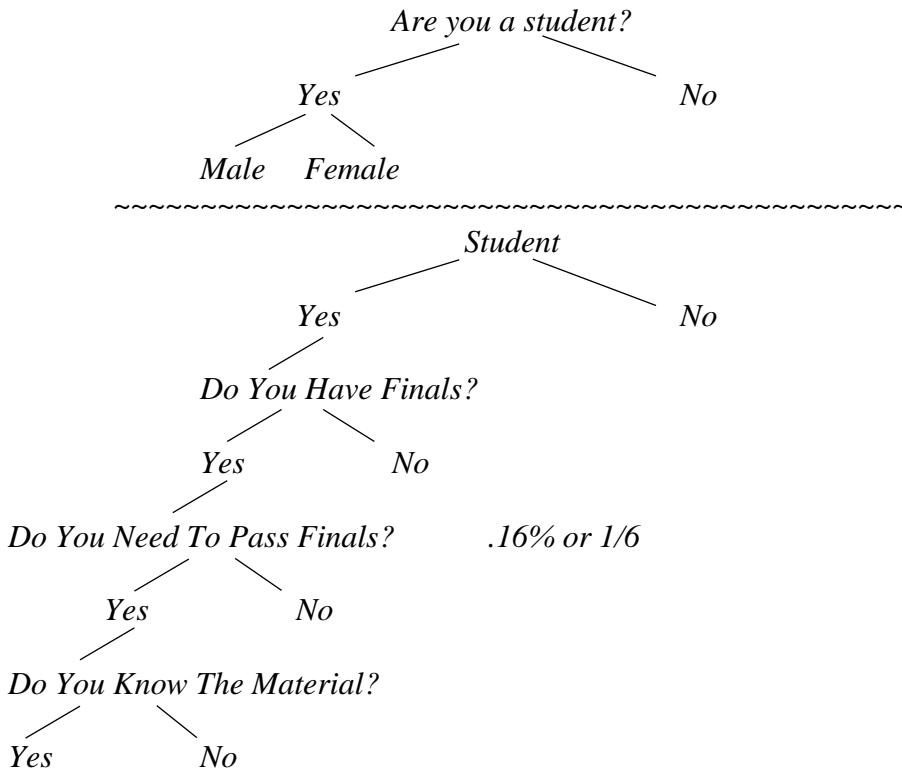
Got W_1 , but prefers M_3 so

Collaboration was in the form of a brief discussion between PSMT1 and PSMT7 (in a dominant participant role) leading and adding humorous commentary about selecting wives. The added humor encouraged student engagement, but did not facilitate critical-creative thinking.

When students completed the polyhedron activity and assignment (Episode #406: In-Security), levels of thinking were Level 5: creating or creative thinking. Multiple approaches and time spans were used by students in assembling a net to a polyhedron. As supported in video evidence, time spans for cutting the net out to assembling ranged from 4 minutes to 30 minutes, based on the levels of collaboration and the students' ability to move into creative thinking. Completed three-dimensional polyhedrons were evidence of focus and perseverance needed to complete the task (growth mindset).

Students utilized different methods and thinking strategies to assemble the three-dimensional polyhedron. Students were identifying which was the easiest way to create the polyhedron as demonstrated in their written reflections. Students were able to accomplish this task (creating a product) by analyzing and evaluating different methods of assembly, and applying prior-knowledge of geometric nets and 3-dimensional figures. PSMTs' responses to reflect the methods used when the polyhedron was assembled are supportive of level 5 creative thinking. For example, PSMT4 stated that "after cutting out the shape, I then folded the shape at all the creases before I taped the shape together. I felt that it may be easier to tape together if it was already folded".

PSMT4: *CART Analysis: Stress During Finals*



Critical-creative thinking, as defined in Figure 2, produced dissimilar video and student work ratings levels in some activities completed for Episode #406: In-Security. While levels of critical-creative thinking were present in student work (Level 5 rating), video evidence of critical-creative thinking was not present for the Classification and Regression Tree (CART) and Steganography activities (Level 2 ratings). Two examples of student work by PSMT4 (CART Analysis) and PSMT5 (Steganography) demonstrated that participants working individually created intellectual and physical artifacts. Video evidence of collaborative critical-creative thinking (growth mindset) was not obvious to the raters. PSMT4 stated, “The logic we used were basic yes or no questions about how stressed you might be taking final exams. Different variables such as whether or not you know the material or if you even need to pass the final could have an impact on stress level. We used probability (.16% or 1/6) to find whether or not you might be stressed.”

When questioned about episode #406: In-Security, five students (PSMT1, PSMT2, PSMT3, PSMT5 and PSMT6) indicated that learning would be facilitated by the connections made between the episode and the mathematics involved in the activities. PSMT4 and PSMT7 (neither student self-reporting as kinesthetic learners who prefer hands-on activities) indicated that student’s learning would somewhat be facilitated. PSMT4 related more to the activities that required logical thinking, such as the CART analysis, than the hands-on creation of the polyhedron.

In Episode #506: Magic, Activity #1, volume of cylinders and force as a product of volume, students were provided with formulas for volume and six problems requiring calculation from graphical representations. This activity seemed to encourage reliance on prior knowledge (or lack thereof) and formulaic learning; participants asked questions such as “what is the formula for...” in geometry activities. Without exception, all participants utilized the provided formulas and calculators to find the solution to each problem or a formulaic approach to solution finding without application of knowledge of specific mathematical processes in real world examples (connection back to the *Numb3rs* episode). Hence, the application of critical-creative thinking was not present nor influenced by the edutainment component. PSMT7 demonstrated some struggle with the calculations, specifically in differentiation of the ‘Base’ versus the ‘Volume’. PSMT7, who described himself as having a preference for group work, did not benefit from the non-interactive approach the other students chose to take for this activity. The gaps in his mathematical knowledge of calculation of volume of cylinders were not addressed or solution-finding facilitated in this instance. The scene from the episode did not provide a point of reference to promote discovery learning.

With a demonstrated clear understanding of the mathematical concept of calculation of cylindrical volume and fluency in calculator usage, PSMT6 utilized value substitution and recorded his solution in a matter of minutes.

Prior knowledge, rather than connections made to the episode, facilitated PSMT6 in finding solutions. Evidence of critical-creative thinking was not evident, but rather rote memorization and procedural application. Activity 1 included the 'Hydraulic Press' problem. Students were given the following background information from the episode and about the mechanical aspects of a hydraulic press. "A hydraulic press is a machine made of two pistons with different cross sectional areas (a and A), which is used to lift large weights or compress material. The ratio of the distances moved and the ratio of the forces are both equal to the ratio of the areas of the pistons". Additionally, formulas for force were provided.

Although six of the seven participants arrived at the same solutions, PSMT2, arrived at a completely different solution. PSMT2's dominant language is Spanish and she prefers to work with a partner who is willing to translate concepts and phrases that do not have readily available cognates or are easily recognizable, such as a hydraulic press. For this activity, all participants chose to work individually without discussion, which may be a contributing factor to a differing calculation and application of the formula. It was apparent that rote memorization and application of formulas can be faulty without relevant background knowledge or points of reference, even though the problem was rooted in a reference from the episode. The edutainment component did not provide added value leading to critical-creative levels of thinking or accuracy in finding solutions for Activity 1 problems.

Evidence of higher order thinking skills at the critical-creative levels (3 and below ratings) for either video or student work samples was not evident in Episode #506: Magic, Activity #2. In traditional approaches to mathematical teaching, concepts are sequenced to support building of concept knowledge. In Activity #2, the concept of "Blood Splatter Trigonometry" and "Volume and Force" were introduced randomly and out of context. When faced with a new concept without supporting instruction or context, students were subjected to an environment inhibiting critical-creative thought. However, background information and the diagram provided did make connections to the episode.

Video evidence demonstrated searching for understanding of the task in student questions such as "Do you understand what the problem is asking?" Looking for a traditional formula approach was evidence of fixed mindset approaches. There was a focus on identification of geometric shapes with little reference to the mathematics involved in rotation of 2-dimensional objects to produce 3-dimensional objects.

This was demonstrated in the work samples by PSMT1 and PSMT3. When participants were asked to identify the shapes of two-dimensional cross-sections and three-dimensional objects generated by rotation of two-dimensional objects, PSMT1 responded, "(1) Circle E triangle for cone, (2) Triangle rotation 360° forms a cone and PSMT3 responded (1) Ellipse - 2 - 0, and (2) Sphere to cone 3-D."

The final activity in the Episode Magic posed a scenario which required pattern analysis. The activity/assignment posed a ‘*thinking*’ problem with resultant critical-creative thinking skills and incorporation of supplemental methods such as, playing cards, drawings and calculators. Ironically, playing cards were not provided as a problem-solving tool, yet PSMT1 introduced the playing cards to the group to test their solutions for correctness (error analysis). PSMT1 has a preference for hands-on activities, which was evident in his approach to the pattern analysis problem.

PSMT4 had struggled with the solution finding process until PSMT1 introduced the playing cards. Following the card demonstration, PSMT4 added the element of calculator use, whereas PSMT6 included pictorial representations in his problem solving. Collaboration among students was a critical component for answering the posed question, "What is the best hand?" Observations indicated that learning is facilitated by carefully assessing and selecting appropriate tools which will be provided to students to facilitate problem solving, including supporting edutainment segments. PSMT1, PSMT3 AND PSMT5 stated learning was facilitated with the connections made to the episode. The other students indicated learning would somewhat be facilitated with the inclusion of the *Numb3rs* episode.

Discussions

Participant responses indicated student learning overall was facilitated by introduction of edutainment as a technological, pedagogical tool. However, it is noted that all participants are mathematics majors (extraneous variable) and the results may be different for a study sample with greater diversity of disposition toward mathematics and mathematics learning, as well as levels of content mastery. The challenge of planning/developing any mathematics activity/assignment is to know and understand the targeted students’ mathematical disposition and skill mastery levels prior to designing the activity/assignment.

As previously stated, levels of thinking appeared to be products of the design of the activity/assignment. If designed to require skills and thinking levels related to fixed mindsets (example, formula-based), then students typically responded from a positioning stance dictated in design of the activity/assignment. It is important to identify extraneous variables which may have contributed to ratings assignment and learning utilizing critical-creative thinking manifested in fixed and growth mindsets, as well as student engagement levels. These variables were not consistently present throughout the study, yet may have had impact on levels of critical-creative thinking in some instances and therefore, warrant recognition.

In response to the research question “What factors contribute to encouraging or discouraging critical-creative thinking?”, rigor of content in design of activities/assignments, connections made to episodes, and the

manner in which content was presented may or may not have presented obstacles to or catalysts for critical-creative thinking. Although all participants are mathematics majors, the study took place in a course focusing on pedagogy rather than pure content.

Variables in collaboration that contributed to discussion dynamics and possibly to levels of critical-creative thinking were: (1) emergence of one to two dominant participants. Roles evolved from interaction and individual personalities. Dominant participants tended to pose “*what if*” questions and propose approaches. Although willing to listen to other participants, dominant participants tended to guide the collaboration in specific thinking. Not surprising, but rather another variable that may have impacted moving in and out of a growth mindset. (2) Males were more dominant than female participants, with one exception. One female participant became a source of prior knowledge and the guide for discussion of the SAS geometry problem. It was not obvious why female participants were not more frequently in dominant roles; (3) as an evening course, timing may or may not have had an impact; and (4) the impact of frustration levels when problem solving was noted.

Dweck (2008) discussed inclinations to face challenges and mindsets to persevere (conative disposition). As activities were approached and frustration levels increased, there were two reactions - reliance on other participants or movement to critical-creative thinking. Both reactions resulted in ‘*creation*’ of intellectual and physical artifacts (Polyhedron) and thus, transitioning to growth mindsets. These reactions substantiated a response to “How does edutainment affect student engagement in problem-solving and help PSMTs transition from fixed mindsets to growth mindsets?” that edutainment contributed to critical-creative thinking or growth mindsets.

With consideration of the aforementioned variables, the results indicated that generally the episodes contributed to student learning by providing a plausible application of math and serving as a point of reference. The written assignments varied in knowledge and skill levels and the students generally responded based on those levels. In response to the research question: “How does embedding an edutainment learning tool and strategy [Numb3rs] influence PSMTs’ thought process and transition to a critical-creative thinker?”, the higher the challenge, the increased critical-creative thinking occurred. If the activity required basic calculations (volume of cylinders, force and distance used in hydraulic press), the students responded with lower levels of thinking. If the activities specifically required students to create (polyhedron or CART), the students responded utilizing critical-creative thinking skills.

As mathematics educators of 21st century learners, we have the responsibility of designing lessons that engage our students and make the learning ‘*sticky*’ (Heath & Heath, 2008), while targeting the encouragement of critical-creative thinking. The technological, pedagogical approach of

edutainment will only be effective when extraneous variables are taken into account (such as positive defiance). Additionally, content connections utilizing an entertaining platform may guide teachers as they address the needs of learners in a technologically driven culture, but the connections must relate to students' diversity and background knowledge/perspectives.

Mathematically-based television segments appear to benefit pre-service mathematics teachers, and should be incorporated into pre-service mathematics methods training and presented as a tool/strategy to teach varying content objectives from a Technological, Pedagogical, and Content Knowledge (TPCK) perspective (Koehler & Mishra, 2009). However, it is recommended that the activities be directly related to carefully selected episodes and to encourage critical-creative thinking. Caution is suggested in the selection of the television series; the viewing content/story lines of *Numb3rs* is not intended for audiences below the ages of 13. By integrating edutainment as a tool and strategy, movement away from the syndrome of 'teaching as I have been taught' may be the beginning of a paradigm shift in mathematics teaching.

This study highlights how integration of *Numb3rs* (edutainment) facilitates learning through critical-creative thinking. Our study suggested that *Numb3rs*, as one of many teaching and edutainment tools, can facilitate critical-creative thinking, increase engagement and transition from fixed mindsets to growth mindsets. Research has firmly established that quality educational television programming can have significant positive effects on cognitive and social development (Kirkorian & Anderson, 2008; Mares & Wordard, 2005). Educators should strive to provide students opportunities to learn mathematics concepts connecting with real-world scenarios through applications such as *Numb3rs*. The benefit of using mathematically-based television programs is supported in this study's findings and is a response to various resistances asserting entertainment-education generally has less impact on learning (Resnick, 2004; Rice, 2007). As asserted by Drogos, Kunkel and Wilson (2008, p. 1), "The key is to find programs that contain high quality educational content." Future studies should examine learning effects of edutainment, specifically mathematically-based television programs.

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