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Analysis of Content and Digital Media Infusion Quality in Integrative STEM Education

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Abstract

This content and digital media analysis study was conducted within a graduate level course involving experienced science, technology, engineering, and mathematics (STEM) education practitioners. Participants assessed aural/visual proposals producing an overall score, a content score, and a digital media infusion score. The scores were tabulated and analyzed for assocations within assessed clusters, specific evaluative considerations when factoring overall score, and diffenences among associative clusters. It was determined, through formulation of the Spearman's Rho correlation matrix and further analysis through the Fisher *z*-transformation output, that experienced STEM educator content score correlation coefficients were statistically higher than the experienced STEM educator digital media score correlation coefficients.

Keywords: At-risk implications; Content analysis; Digital media; STEM education

Introduction

Dynamic media application and instructional infusion in elementary and secondary settings has broad utility for a range of learners, furthering educational intensity while propelling learners within science, technolog, engineering, and mathematics (STEM) education disciplines (Ernst & Clark, 2009). Documented benefits of digital media incorporation range from content comprehension and retention (Lippincott, 2002) to emergent literacies (Hisrich & Blanchard, 2009) to impact on overall school culture (Rose & Meyer, 1994). Expansive effectiveness of the use of dynamic learning tools for at-risk and underserved learners, as well as traditional learner groups, is well documented (Tettegah & Mayo, 2005).

Digital media-based technology implementation in K–12 STEM education classrooms has pervasive presence, created by the identifiable educational value and subsequent adoption of standard sets/electronic technology accessibility (Irving & Bell, 2004). Often there is an expectation or a localized pressure to further build digital and media technology applications into STEM education courses or paths of study. Barone and Wright (2008) identify a demand or expectancy of digital and media tool use in classrooms where many K–12 educators feel unprepared for facilitation or practice. Select teacher preparation programs do provide prospective teachers with direct exposure to the implementation of digital technology learner applications (Banister & Reinhart, 2012), but these remain infrequent at the appropriate depth.

Kraidy (2002) identifies that learner modes of cognition are further formed through digital application enabled by instructional media. Digital visualization of information supports the understanding of nonrepresentational ideas while concurrently promoting conceptual abstraction. Initiatives within science education; technology, engineering, and design education; and mathematics education that build or implement digital tools for educational consumption highlight engagement and heightened learner outcomes (Sun & Metros, 2011; Busby, Ernst, & Clark, 2011; Ke, 2006; Squire, Barnett, Grant, & Higginbotham, 2004). However, quality work indicators through established assessment criteria and factors/assessment protocols that constitute a gauge of conceptual abstraction are commonly unspecified.

Digital Content Analysis

There are many aspects that can serve as "distractors" pertaining to the evaluation of digital content. For example, in a 2008 study, Eysenbach recognized that refined design features and well-composed and aesthetically pleasing static graphics had a sizeable effect on identified credibility of information. Similarly, in a study investigating the evaluation of web-based material (Rieh, 2002), structure, graphics, and organization were the most prevalently cited characteristics applied to evaluating quality. In a 2012 study, Watson and Ernst uncovered that for knowledgeable STEM education evaluators, content has a stronger association with overall evaluation than digital media infusion. While acknowledging the separation and unique differences between the experienced evaluators of the Watson and Ernst (2012) study and the novice evaluators of the Eysenbach (2008) and Rieh (2002) studies, the large separation and seemingly contradictory findings should be noted.

With undisputed advantages of the use of digital media for STEM education learners, the continual demand for dynamic means of learner interface, and the common creation of digital-based student learning artifacts, it is reasonable to seek confirmation that knowledgeable STEM education professionals are in fact able to determine the credibility of digital artifacts. Specifically, as suggested in the Watson and Ernst (2012) study, we need to answer the question: Are STEM education professionals proficient in gauging quality of content over quality of infusion of digital media in the dynamic presentation of information? In efforts to explore this issue, a study was proposed and conducted involving STEM education professional examination of dynamic media digital artifacts.

Participants

Participants in this content and digital media analysis study were enrolled in a Foundations of STEM Education course at the graduate level. The course was housed within a school of education in an Integrative STEM Education Program. Participants in the study were pursuing one of five graduate credentialing or degree options: Integrative STEM Education Graduate Certificate, Master of Arts in Education, Education Specialist, Doctorate of Education, or Doctor of Philosophy. For the purposes of this investigation, differentiation of degree option was established only for description of participant demographical makeup. Typically, the Foundations of STEM Education Course consisted of first year students, most of which had previous K–12 STEM education classroom experience or were current in-service STEM educators. Participants enrolled in Foundations of STEM Education during this study were predominately licensed educators with current or previous K–12 experience. Three participants did not have immediate or previous K–12 classroom experience and were professionals in engineering or engineering education. Table 1

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provides participant demographics pertaining to graduate degree pursued, gender, semester enrolled in the program, and indication of previous K–12 STEM education classroom experience.

Table 1
Demographics of Study Participants

Degree *n* (%)	Gender *n* (%)	Semester *n* (%)	STEM Ed. Classroom Experience *n* (%)
Cert. = 4 (13%)	Male = 13 (40%)	First = 22 (69%)	Yes = 29 (91%)
M.A.Ed. = 15 (47%)	Female = 19 (60%)	Second = 7 (22%)	No = 3 (9%)
Ed.S. = 2 (6%)		Third = 3 (9%)	
Ed.D. = 3 (9%)		Fourth = 0 (0%)	
Ph.D. = 8 (25%)			

Note. $N = 32$

Methodology

The intent of this research study was to analyze the relationships among content evaluation, digital media infusion, and overall evaluation of electronic media presentations. There was a single overarching question that guided this study:

> *Is there a distinguishable difference between association of content/overall analysis and association of digital media/overall analysis by STEM education professionals?*

The study methodology consisted of drafting and submitting a proposed research protocol to the governing Institutional Research Board. The research protocol was reviewed and administratively approved. Once official approval was received, recruitment of study participants began. Individuals that were enrolled in a course entitled Foundations of STEM Education were invited to participate in the study examining how a knowledgeable audience evaluates a proposal developed with digital media tools. The participants were informed that there were no risks involved with participating in the study and that the submitted assessments were completely anonymous. Participants were also informed that participation in the study would have no impact on their grade either in the course or on the student-generated Integrative STEM Education Strategies Aural/Visual Proposal.

Consenting participants were asked to complete a three-part assessment form in which they were to provide three different categories of evaluation scores (overall score, content score, and digital media infusion score) on the Integrative STEM Education Strategies Aural/Visual Proposals. This study was conducted during the 15th week of a 16-week semester in order to establish course content as well as permit full development of course participant aural/visual proposals. Participants were provided online access to the proposal assessment form and asked to evaluate their randomly generated group members. Each group consisted of approximately five members (in two groups there were six members) that would then evaluate one another's work. Twenty minutes were allowed for evaluation of the three aspects of the aural/visual proposals during which time participants finalized and submitted their scores.

STEM Education Foundations Course

The Foundations of STEM Education course is a requirement in the Integrative STEM Education Program at Virginia Tech. The course approaches science, technology, engineering, and mathematics education content and practices from a distinct discipline-based historical and theoretical angle. As a result of the evidence-based material, students often form or re-form viewpoints and approaches concerning STEM education and its organizational structure in K–16 education. In the course, students discuss topics such as Science Education, Technological Literacy, Establishing K–12 Engineering Education, Mathematics Education Structure and Approach, Unwrapping STEM Education Standards, Curricula in STEM Disciplines, and Natural Integration for STEM Disciplines and Students At-Risk. Course requirements included Forum Responses consisting of posted questions within the learning management system that related to the previous class session's discussion. There were five Forum Responses required over the course of the semester. In addition to each individual post, participants were expected to review posts of classmates and provide feedback or questions where the individual deemed it appropriate. The Origins Report assignment required students to select from a list of instructor-generated STEM discipline topics, research that topic, generate a podcast, make the podcast accessible via the learning management system, and address the questions of peers based on the content of the work. In the required Reading Summaries assignment, participants gradually read a list of 22 research articles and submitted five Reading Summaries considering what the reading introduced, what the reading proposed, and what impact or implications the reading had on the identified STEM-based educational discipline. Participants also completed an essay-format course midterm examination and final examination where course content, readings, and discussions were used to answer essay questions. Finally, students completed and submitted an Integrative STEM Education Strategies Aural/Visual Proposal. In this study, the strategies proposals serve as the dynamic media learner artifact being evaluated by participants.

Aural/Visual Proposal

The dynamic media learner artifact that was developed and evaluated by study participants consisted of STEM education content based on directly challenging or expanding upon an approach or a model discussed or referenced during the STEM Education Foundations course. The models discussed or referenced through course presentations, discussions, and readings concern the further promotion and development of integrative STEM education. Participants were urged to consider the following guiding questions pertaining to the information anticipated in the proposal:

- What was the nature of the purposeful integration to occur and at what academic level was it focused?
- What underpinning research or evidence served as the basis for this type of integration?
- How was buy-in created from a local, state, and national level?

There were numerous digital media applications that could be used to develop the aural/visual proposal. Some commonly used applications were Camtasia, CamStudio, Screencast-O-Matic,

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and Screenflow. The applications were specifically used to convey audio content considering the proposal's guiding questions and to present visual material in support of the audio content. Each participant created a 7–10 minute dynamic and persuasive proposal using supplemental audio content, images, graphs, illustrations, and visualizations. Once completed, each participant proposal was made accessible through a course learning management system. A sample aural/visual proposal from a previous Foundation of STEM Education course (not included within this investigation) can be found at http://www.youtube.com/watch?v=BNpUZKXw1V4.

Proposal Assessment Form

The form used by participants to assess the aural/visual proposals consisted of an Informed Consent page, Part A (overall assessment), Part B (assessment of content), and Part C (assessment of digital media infusion). The Informed Consent page reiterated the request for participation, outlined the participant expectations, and addressed potential risks and benefits of the research along with a statement of anonymity and confidentiality. Part A requested researcher-provided proposal identifiers for the project being assessed to directly match with the overall project score identified. The overall scoring scale ranged from 1 (*Low/Poor*) to 10 (*High/Excellent*) followed by a free-response prompt gathering criteria or factors in assigning an overall score to the project.

Part B requested content scores on a scale also ranging from 1 (*Low/Poor*) to 10 (*High/Excellent*). Content analysis considerations were identified on the form as:

1. How well did the author directly challenge or expand upon an approach or a model discussed/referenced concerning the further promotion and development of Integrative STEM?
2. How well did the author address the nature of the purposeful integration to occur and the academic level at which it will be focused?
3. How well did the author address the underpinning research or evidence that serves as the basis for this type of integration?
4. How well did the author address the ways in which buy-in will be created from a local, state, and national level?
5. How well and how accurately did the author use the information presented during the course?

Part C requested digital media infusion scores on a scale also ranging from 1 (*Low/Poor*) to 10 (*High/Excellent*). Digital media analysis considerations were identified on the form as:

1. Is the quality of digital media used supportive of the proposal content?
2. 2) Is the quantity of digital media infusion sufficient to support the proposal content?
3. Are visuals appropriate/supportive of information cited and introduced by the audio?
4. Do audio and video transitions add interest without being distracting?
5. Do supplemental visualizations (e.g., images, animation, video) add interest while supporting information presented?

The web-based form was composed with parameters where participants were not allowed to alter Part A scores once proceeding to Part B. However, participants were permitted to toggle between Part B and Part C and alter scores as they deemed necessary. The form was structured in this way to enable accurate initial establishment of overall criteria without predisposition of the content analysis and digital media infusion recommended considerations.

Data and Findings

The STEM educational content outcome data, digital media outcome data, and overall outcome data were examined to uncover variations, correlations, and differences. A scatter plot (see Figure 1) of content scores with matched overall scores was constructed to provide a visual representation of the array of assessment results for the 125 participant ratings. The scatter plot of the data does not display a complete linear alignment but does exhibit a concentrated grouping uncovering a positive slope relationship of content score to overall score.

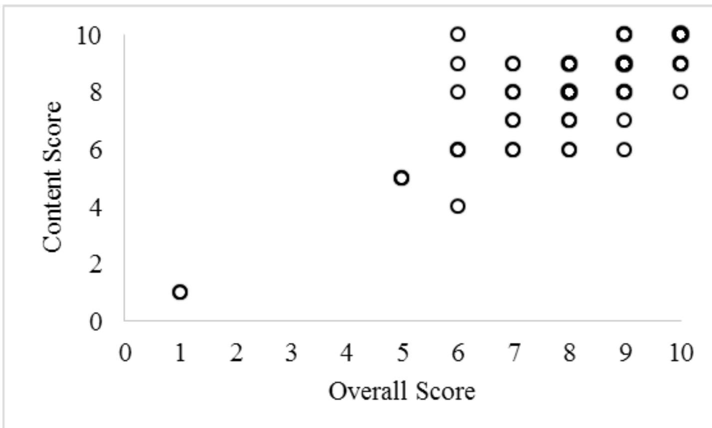

Figure 1. Scatter plot of overall score by content score (n = 125 ratings).

At the conclusion of Part A on the proposal evaluation form, participants were asked to identify specific criteria or factors used in assigning overall scores for projects. Among the 32 unique responses for this prompt, there were seven recurring criteria cited (see Table 2).

Table 2
Recurring Criteria in Assigning Overall Score

Criteria	Occurence
Overall presentation	3
Presentation flow	3
Visuals	3
Clarity	3
Depth	2
Consistency	2
Interest	2

A second scatter plot was generated (see Figure 2), providing a visual depiction of the digital media infusion outcome scores and overall outcome scores of participants. As in Figure 1, the scatter plot does not display a clear linear alignment but does present a concentrated grouping uncovering a

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positive slope relationship of digital media infusion score to overall score.

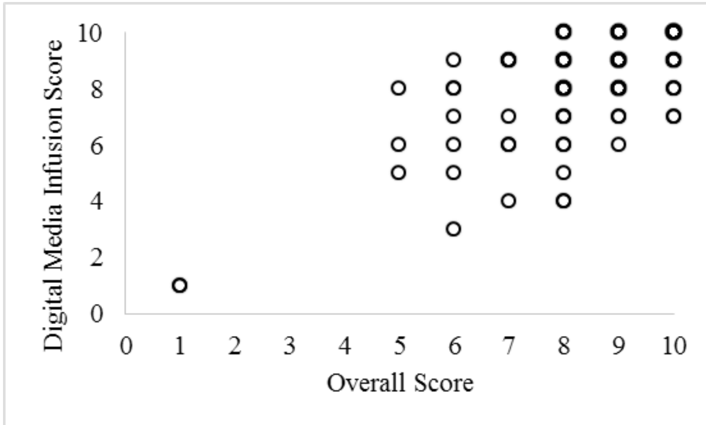

Figure 2. Scatter plot of overall score by digital media infusion score (*n* = 125 ratings)

Finally, a third scatter plot was generated (see Figure 3), providing a graphical representation of the digital media infusion outcome scores and content outcome scores of participants. As in Figure 1 and Figure 2, the scatter plot does not display a well-defined linear alignment but does depict a concentrated grouping uncovering a positive slope relationship of digital media infusion score to content score.

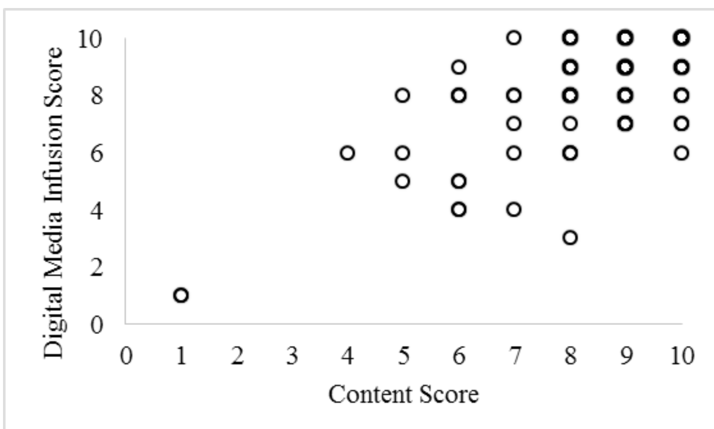

Figure 3. Scatter plot of content score by digital media infusion score (*n* = 125 ratings).

In this study, the sampling was not randomly conducted. The participants were selected for their expertise. Therefore, the distribution of the data is nonrandomized, categorically identifiable as a non-Gaussian population. Additionally, the evaluative scores in this study were ordinal variables considering meaning of different levels within the instrument classification may not be precisely the same for different individuals. Based on the nonparametric distribution and the nature of the data, Spearman's rho was selected as the analysis tool to tabulate correlation in place of Pearson, which is used for continuous variables (Sheskin, 2007). Spearman's rho measures the strength of the linear relationship between two variables when the values of each variable are rank-ordered (Weinberg & Abramowitz, 2008), and it calculates a correlation coefficient on rankings rather than on tabulation of the raw data (Muijs, 2011).

The correlation coefficients were calculated (Table 3) between each of the paired variables using Spearman's rho because the variables were ordinal in category. The Spearman's rho between content score and the overall score was 0.757, which was significant at the 0.01 level. This indicates a strong positive correlation between the two variables. As the evaluation of content increases or decrease, the overall evaluation of the proposal has a tendency to change to the same direction proportionally. There was a moderate positive correlation between digital media infusion and overall score; the Spearman's rho was 0.541 and was significant at the 0.01 level. Therefore, the overall evaluation has a tendency to increase or decrease together along with evaluation of content. A Spearman's rho of 0.498, significant at 0.01 level, was shown between digital media infusion score and content score, suggesting a moderate positive association between how the participants evaluate content and the infusion of digital media tools. The evaluation of content and the digital media infusion tend to increase or decrease together, although not in a directly proportional manner.

Table 3
Spearman's Rho Correlation Matrix

	Overall score	**Content score**	**Digital media score**
Overall score	--	0.757*	0.541*
Content score	0.757*	--	0.498*
Digital media score	0.541*	0.498*	--

*Correlation is significant at the 0.01 level (2-tailed).

The Fisher *z*-transformation is utilized to assess statistical differences, if any, between the content score/overall score correlation coefficient and the digital media score/overall score correlation coefficient. When a stated coefficient is greater than another stated coefficient, *z* will tabulate as a positive sign; alternatively, *z* will tabulate as a negative sign (Lowry, 2013). In the case of the content score and digital media score assessment of significance in Table 4, the *z*-statistic was tabulated as a positive sign while its corresponding tabled *p*-value was < 0.01, indicating a statistically significant difference between the two tested correlations. It was determined that the content score correlation coefficients are statistically higher than the digital media score correlation coefficients.

Table 4
Fisher Z-Transformation

Correlation difference	***n*1**	***n*2**	**Diff. Est.**	***z*-stat.**	***p*-value**
Content Score – Digital Media Score	125	125	3.53	3.0	< 0.01

Conclusions

As implementation of electronic learner artifacts in educational environments becomes more prevalent, it is important for educators to develop, maintain, or expand upon their abilities to distinguish between creatve digital media incorporation and the informative or descriptive

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nature of dynamic media-based content. In this investigation, positive slope relationships of content scores to overall scores as well as digital media infusion score to overall scores were identified. Further, significant associations were found between both content scores and overall scores in additon to digital media infusion scores and overall scores. Both content and digital media infusion are clear contributors to overall analysis outcomes for STEM education professionals. However, based on the Fisher *z*-transformation, a statistically significant difference between the content score correlation and the digital media score correlation was identified. This suggests that the content score was a firmly associated indicator of overall content credibility while digital media infusion was not as strongly associated based on the evaluations performed by the group of STEM education professionals. This study showed that there was a distinguishable difference between association of content/overall analysis and association of digital media/overall analysis for STEM education professionals.

Although there was a separation in circumstance and analysis technique from this study, the finding of Watson and Ernst (2012) that content possesses a stronger association with overall evaluation than digital media infusion was confirmed. Further reinforcing this conclusion is the free-response identification of overall evaluative criteria in Part A of the proposal assessment form. Based on the overall participant-identified criteria for the aural/visual proposals, content was a stronger initial consideration when evaluating the proposals given that all seven recurring factors were features central to content. Interest and visuals are partial contributors to digital media but not fully exclusive to that construct. Further investigation is needed in efforts to establish evaluation trends underneath categorizers such as specific STEM education discipline and the nature of media incorporated (e.g., static, dynamic, 2-D, 3-D, and interactive). Also, the integrative mindset and adopted practices of STEM educators working in multiple disciplines are factors that warrant further investigation in terms of evaluative quality and approach. This is information that curricula leaders, professional development providers, and preservice education programs can enact in evidence-based decision making processes when structuring inititiatives, configuring platforms, and implementing instruction. Further building digital media-based appliations into instructional practice and experiencing its vast engagment benefits, while also maintaining a strong conceptual content evaluative base to clearly and accurately document STEM learning, is the optimum outcome.

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