# Collaborative Information and Multimedia to Assess Team Interaction in Technology Teacher Preparation

Technology influences elemental communication methods, results, and artifacts (Rogers & Thomas, 1997). Technological innovation obliges educators, students, and consumers to alter approaches to a variety of issues spanning from the way hierarchal relationships are perceived to the manner and means that individuals use to communicate. The utilization of information technology to assist communication and collaboration has become a central theme in information systems research and practice (Olesen & Myers, 1999). Rising information and communication technologies could considerably enhance interaction and collaboration.

A situation is identified as collaborative in nature when three conditions are met: "if peers are (i) more or less at the same level and can perform the same actions, (ii) have a common goal, and (iii) work together" (Dillenbourg, 1999, p.9). Communication and decision assembly are the two most prevalent actions executed by groups (Fisher, 1974; Mills, 1967, as cited in Baker, 2004). Multifaceted tasks and assignments that necessitate various proficiencies and abilities have been identified as most efficiently performed by a group. The logic and associated evidenced-based findings identify that a group's problem-solving skills and knowledge exceed those of any single contributor (Neilson, 2002). Edmondson, Roberto, and Watkins (2003) identify that team-based approaches and structures further the origination of innovative ideas and satisfactory alternatives, enabling diverse considerations to satisfy complex tasks and functions.

There are distinct advantages and disadvantages in operating with electronically linked groups. Structural and member advantages refer to groups' abilities to communicate virtually anytime and support active participation by each member (Brown, 2000). However, individual member and group-level conditions exist primarily due to scaled down exposure to visual and auditory contact, as well as lessened synchronous contact, although many contemporary information and multimedia technologies permit visual, auditory, and synchronous contact.

Information and communication technology practices and uses have developed into progressively more successful approaches in addressing individualistic learning needs, although meeting the needs of learning groups

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remains a challenge (Soller, Ogata, & Hesse, 2007). Initiated in the early 1980s, research about the method and approach of peer interaction assisting the development of understanding and learning has been pursued (Littleon, 2000). Collaborative learning research identifying specific educational effects has been illustrated in conditions of conceptual change or increased self-regulation (Amigues, 1987; Blaye, 1988; Gilly, 1989; Roschelle, 1992; Pea, 1993, cited in Dillenbourg, 1999). However, documentation of the understanding of true team dynamic and associated knowledge formation has not been clearly considered and accounted for.

## Communication Collaborative Technologies

Regardless of the degree of learner preparedness, subsequent knowledge is based on how well students understand the learning process, with feedback, achievement, motivation, and expertise as acting elements. Team-based learning naturally incorporates each of these facets through its structure (Hills, 2001). Hills (2001) further identifies that, in an actual group structure, these naturally occurring facets must take on varied dynamics encompassing team planning, internal actions, relationships with others outside the group, and self measures of progress. Collaborative information technologies are broadly defined as electronic communication means that enable cooperation amid individuals engaged in a common mission or specific task (Khosrow-Pour, 2002). Through the incorporation of visual elements, communication technologies can further stimulate learning (Hamm & Adams, 1992). Targeted research by Andres and Akan (2010), examining the effects of technology-mediated learner collaboration, found that technology tool specification and incorporation, although not solely, promotes knowledge formation and application in team problem solving. In a study on innovations in remote learning design through collaborative online learning activities, Armellini and Aiyegbayo (2010) identify, through the use of web-based media tools (wikis, blogs, GoogleDocs, etc.), that activity design led to instantaneous instructor adoption and incorporation into the classroom. The study attributes this incorporation to learners being provided a mechanism to take part in, and benefit from, active knowledge construction.

For the purposes of this research study, applications that permit documents and imagery transfer, video communications, audio communication, and text-based communication (whether synchronous or asynchronous) are universally identified as collaborative information and multimedia technologies. This study introduced students to Google Documents, Skype, Wikis, Elluminate, Doodle, and Ning as information and multimedia technology applications to collaborate with classmates/peers (see Table 1 next page). Although course sections had traditional face-to-face meetings and laboratories, one section of participating students utilized the selected information and multimedia technology applications.

**Table 1**
*Information and Multimedia Technology Applications*

| Application | Description |
|---|---|
| Google Documents | Documents, spreadsheets, forms, and presentations can be created, shared, and/or exported within Google Documents. Google Documents automatically saves files with a revision history view option. |
| Skype | Skype is an internet protocol audio and video communication provider. |
| Wikis | Wikis permit web pages to be formed for the purpose of editing collaboration. |
| Elluminate | Elluminate has a wide range of uses, spanning from social networking to video conferencing. |
| Doodle | Doodle is a group meeting scheduler to efficiently identify common availability among team members. |
| Ning | Ning serves as a place for social networking categorized by issues, topics, and initiatives. |

## Research Questions

A technology and teamwork study conducted by Palit and Stein (2008) identified that effective use of technology in a collaboration requires contextual knowledge and skills. One limitation acknowledged in their investigation was that student participants were deficient in information and communication technology proficiency. Palit and Stein recommend the inclusion of lessons/exercises to demonstrate how skills may be transferred into the context of their group experiences. They also identified that maintaining an operational knowledge of technological innovations (e.g. Information and Multimedia Technology Applications) should be paired with foundational skills and competencies associated with teamwork and collaboration. Further, developing practical teaming knowledge through experiences permits students to properly select and utilize technological applications in academic and professional settings. These findings and recommendations invoke lines of examination associated with technology teacher preparation and the potential uses of information and multimedia technology application, not only to extend student interactions outside of class, but also to promote knowledge formations associated with teaming and collaboration.

This research study was designed to investigate and identify the impacts, if any, that web-based information and communication collaborative technologies have on team-established interaction and team knowledge formation. Considering the Palit and Stein (2008) recommendation, four research questions were posed to specifically guide this study.

1. Are there identifiable differences in how students interact with group members before and after being presented with collaborative information and multimedia teaming technologies?
2. Is there an identifiable difference in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies interact with group members?
3. Are there identifiable differences in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies form team knowledge?
4. Is there an identifiable difference in students' team knowledge formation before and after being presented with collaborative information and multimedia teaming technologies?

Associated investigational hypotheses were derived to provide specific evaluation of research questions 1, 2, 3, and 4.

- There is no difference in how students interact with group members before and after being presented with collaborative information and multimedia teaming;
- There is no difference in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies interact with group members;
- There is no difference in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies form team knowledge; and
- There is no difference in students' team knowledge formation before and after being presented with collaborative information and multimedia teaming technologies.

## Study Participants

Students enrolled in university advanced digital media sections were selected to participate in this team interaction and knowledge formation study based on enrollment and willingness to participate. The advanced digital media course serves as a required course in the re-visioned Technology, Engineering, and Design Education curriculum for Technology Education licensure. This course provides students with advanced knowledge and skill in the digital and interactive media industry. Emphasis is placed on advanced audio and video design. This course fulfills the communication technology requirement, while also targeting competencies in the Trade and Industrial endorsement area of Digital Media. The advanced digital media course is designed to build upon foundational knowledge and skill, gained in the introduction to digital media course, through advanced media study and application. Technology education at North Carolina State University has both a teacher licensure option, as well as a concentration option in graphic communications. However, both options are categorized as preservice technology and trade and industrial teacher education designations. The advanced digital media course for this study included both preservice teacher education options. Tables 2 and 3 provide the participant demographics of the advanced digital media sections participating in this team interaction and knowledge formation study.

**Table 2**
*Digital Media Section One Demographics*

| | | |
|---|---|---|
| **Gender** *n* – (%) | Male | 16 – (94%) |
| | Female | 1 – (6%) |
| **Age Range** *n* – (%) | 18-20 | 10 – (59%) |
| | 22-29 | 5 – (29%) |
| | 30-39 | 0 – (0%) |
| | 40-49 | 0 – (0%) |
| | 50+ | 1 – (6%) |
| | Not Specified | 1 – (6%) |
| **Major** *n* – (%) | Technology Education | 7 – (41%) |
| | Technology/Graphics Educ. | 7 – (41%) |
| | Science, Tech., & Society | 1– (6%) |
| | Parks, Rec. & Tourism | 1– (6%) |
| | Mechanical Engineering | 1– (6%) |

**Table 3**
*Digital Media Section Two Demographics*

| | | |
|---|---|---|
| **Gender** *n* – (%) | Male | 16 – (76%) |
| | Female | 5 – (24%) |
| **Age Range** *n* – (%) | 18-20 | 12 – (57%) |
| | 22-29 | 9 – (43%) |
| | 30-39 | 0 – (0%) |
| | 40-49 | 0 – (0%) |
| | 50+ | 0 – (0%) |
| **Major** *n* – (%) | Technology Education | 14 – (67%) |
| | Technology/Graphics Educ. | 7 – (33%) |

## Methodology

The research team submitted a research proposal and was granted Institutional Review Board administrative study approval. Advanced digital media course instructor permission was acquired for the only two course sections offered. The advanced digital media course offering is limited to spring semesters, resulting in an annual offering of two simultaneous sections in the spring. One of the two digital media course sections was designated the control group, implementing the non-supplemented course curricula. The remaining digital media course section was designated as the treatment group. The treatment group was offered an identical course curriculum with the exceptions of a pretest and presurvey administered in week four of instruction, a one hour teaming technology orientation in week five of instruction, and a thirty-minute follow-up on specific uses of teaming technologies in week six of instruction. The one-hour teaming technology orientation consisted of a professional instructional technology and media specialist introducing the selected information and multimedia technology applications (identified and described in Table 1). The specialist created a single web-based resource for student access to applications and associated tutorials pertaining to the selected collaborative technologies. One week after the initial one-hour teaming technology orientation, the specialist hosted an in-class thirty-minute follow-up that included specific student questions and demonstration-based answers. Additionally, the control group and the treatment group were administered a teaming survey and a teaming test in week 15 of instruction. The treatment group was issued an additional team dynamic supplemental survey.

Both the treatment and control groups met a total of 23 times over the course of the semester using a standard lecture/laboratory course format. The course cognitive evaluations consisted of four periodic examinations and a cumulative final examination. The performance assessments were separated into team-based assignments, projects, and laboratories. Assignments consisted of two video projects that challenged students to brainstorm, formulate ideas, storyboard, and produce 30-second video solutions given defined criteria associated with viewing audience, time constraints, and intent.

Course projects, all of which were team-based, included storyboarding, instructional still video, documentary photography, and documentary video. The storyboard project introduces students to a variety of preproduction methods, which are widely used in today's audio and video production markets. At the conclusion of this project, students encountered much of the preproduction process in the completion of a storyboard. The Instructional Still Project introduced students to a variety of preproduction, production, and postproduction processes and methods important in achieving directed viewer effect. This project required students to utilize existing knowledge and skill to plan sequences, originate imagery, and generate audio. The Documentary Photography Project introduced students to a method of image capture that provides a record of social and political situations. This project required students to utilize existing knowledge and skill to convey a message through digital still photography. Similarly, the Documentary Video Project introduced students to a method of video capture that also provides a record of social and political situations. There were two primary approaches to documentary video—anthropological and historical. The anthropological approach shows people, institutions, and cultures as they are. The historical approach tries to bring to life significant people and events from the past. This project required students to utilize one of these documentary approaches, existing knowledge, and existing skill to convey a message through video.

Team-based laboratories consisted of a live video assignment, a live audio assignment, an original audio assignment, and a satellite communications assignment. The live video production laboratory gave students an opportunity to create, develop, and produce a live news television program. The laboratory was designed to allow the students to think and work in a "live television" environment. After completing the laboratory, the intent was for students to have gained a better appreciation for the technical requirements involved in producing a news television program. The live audio production laboratory provided students with an opportunity to create, develop, and produce a live radio program. After completing the laboratory, the intent was for students to have gained a better appreciation for the input and technical functions associated with creating and producing a live radio program. The audio development laboratory introduced students to technologies, which included audio composition, alteration, enhancement, and sweetenings, in a practical application used in today's industry. The Satellite Communications laboratory gave students a chance to learn about one aspect of satellite communication through the use of global positioning systems (GPS). Students were given the opportunity to use a synched digital camera GPS in order to complete a photography scavenger hunt.

## Instrumentation

The Team Perception of Collaboration (TPC) assessment measures team interaction among group participants. The assessment is composed of 21 statements where participants are instructed to choose an option (ranging from never to always) that most accurately categorizes the description of their team. The option scale consists of 5 choices, 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Frequently, and 5 = Always. Instrument procedure requires subjects to be placed into groups and presented with collaborative tasks to capture team interaction specifics pertaining to listening, differences/conflicts, decision assembly, criticism, communication, group structure, and efficiency. Powers, Sims-Knight, Topciu, and Haden (2002) identified, through instrumentation analysis of the TPC of Arizona State University engineering undergraduates, that the sub-scales demonstrate adequate reliability evidenced by alpha's of .72 for both pre- and posttesting.

The Team Knowledge Test (TKT) assesses team knowledge formation in participants (Palit & Stein, 2009).

> The TKT is a measure intended to assess individual team members' general knowledge of team issues and concepts. The current test was designed for use with an undergraduate college population rather than a corporate population. Its 21 items are designed to sample students' understanding of four domains -- team process, decision-making, communication, and conflict resolution. This test presents a series of hypothetical situations in which the respondent is asked to choose the best [response of four multiple choice] options. (p.309)

A limitation of the TKT instrument design is that it contains carryover and, in some cases, duplicate concepts, although, not for all items. Also, TKT items are in many cases situational and are not always indicative of productive teaming elements. Sims-Knight et al. (2002), as cited in Palit & Stein (2009), state that TKT scale reliability is high as evidenced by a developmental study having a pretest scale Cronbach's Alpha of .78 and a posttest scale Cronbach's Alpha of .76. This is resultant in TKT scale developers recommending a valued overall calculation score.

## Data Analysis and Findings

The first evaluated hypothesis was: There is no difference in how students interact with group members before and after being presented with collaborative information and multimedia teaming technologies. This hypothesis was evaluated in Table 4 using the nonparametric Mann-Whitney test. As indicated by Sheskin (2007), the Mann-Whitney test was selected for this study based upon its assumptions, sampling, non-parametric basis (non-Gaussian population), and the TPC's rank order data set. The test statistic for the Mann-Whitney test was compared to the designated critical value table based on the sample size of each student participant sample. The participant data for both sample sizes was less than 50, denoting that no normal approximation with continuity correction was necessary and the reported p-value is exact. The critical alpha value was set at 0.05 for this investigation. The p-value for the test (0.526) was determined to be larger than 0.05, therefore, the null hypothesis failed to be rejected. The analysis of data suggests that collaborative information and multimedia teaming technologies presentation has no statistically significant impact on how students interact with group members in this sample.

**Table 4**
*Treatment Group Pretest and Posttest Team Interaction (TPC)*

| Treatment Pre- (*n*) | Treatment Post- (*n*) | Diff. Est. | Test Stat. | P-value |
|---|---|---|---|---|
| 21 | 20 | 0 | 416.5 | 0.526 |

The second evaluated hypothesis was: There is no difference in how students presented with, and those no presented with, collaborative information and multimedia teaming technologies interact with group members. This hypothesis was evaluated in Table 5, again using the nonparametric Mann-Whitney test. The p-value for the test (1.00) was determined to be larger than 0.05, therefore, the null hypothesis failed to be rejected. The analysis of data suggests that collaborative information and multimedia teaming technologies presentation has no measurable impact on how students interact with group members in this sample.

**Table 5**
*Treatment Group Posttest and Control Group Posttest Team Interaction (TPC)*

| Treatment Post- (*n*) | Control Post- (*n*) | Diff. Est. | Test Stat. | P-value |
|---|---|---|---|---|
| 20 | 17 | 0.0186 | 2 | 1.00 |

The next hypothesis to be evaluated was: There is no difference in how students presented with, and those not presented with, collaborative information and multimedia teaming technologies form team knowledge. This hypothesis was evaluated in Table 6 using the Kruskal-Wallis Test. The Kruskal-Wallis Test ranks designated elements from lowest to highest in the two designated samples. Kruskal-Wallis was selected over the Mann-Whitney non-parametric test based on the nature of the TKT instrument and resultant data set.

The sampling distribution for the H statistic was used to test the null hypothesis. The calculated values for the H statistic were evaluated in comparison to the critical values to determine if the null hypothesis is rejected or if there is evidence that fails to reject the claim. The H statistic is less than the critical value so the null hypothesis is not rejected. The p-value for the test ($< 0.0001$) was determined to be smaller than 0.05, therefore, the null hypothesis was rejected. The analysis of data suggests that collaborative information and multimedia teaming technologies presentation had a measurable impact on student team knowledge formation, when framed as treatment control study given the student population and sample.

**Table 6**
*Treatment Group Posttest and Control Group Posttest Team Knowledge Formation (TKT)*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Treatment | 21 | 1 | 18 | 25.325 | 15.139137 | < 0.0001 |
| Control | 17 | 1 | 14 | 11.558824 | | |

The fourth hypothesis to be evaluated was: There is no difference in students' team knowledge formation before and after being presented with collaborative information. This hypothesis was evaluated in Table 7 using the Kruskal-Wallis Test. The p-value for the test (0.5174) was determined not to be smaller than 0.05, therefore, the null hypothesis failed to be rejected. The analysis of data suggests that collaborative information and multimedia teaming technologies presentation has no measurable impact on student team knowledge formation when measured in a pretest/posttest format given the student sample.

**Table 7**
*Treatment Group Pretest and Posttest Team Knowledge Formation (TKT)*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Pre-Treatment | 21 | 1 | 18 | 22.225 | 0.41899058 | 0.5174 |
| Post-Treatment | 20 | 1 | 17 | 19.833334 | | |

Supplemental hypothesis testing was conducted for each item of both the TPC and TKT instruments. This was done to specifically identify TPC and TKT item-based differences, not only between the treatment and control groups, but also between the treatment pretesting and post testing. Mann-Whitney results identify that TPC Item 8, “My team ignores conflicts among team members,” exhibited a statistically significant difference between team interaction outcomes between the treatment and control groups, where Items 11, “My team tends to start working without an explicit plan,” and 14, “My team is able to generate potential solutions and evaluate them in an effective and systematic fashion,” exhibited a statistically significant difference between team interaction outcomes between the treatment pretest and posttest. Table 8 displays the supplemental Mann-Whitney results for TPC Item 8, and Table 9 displays the supplemental Mann-Whitney results for TPC Item 11 and the supplemental Mann-Whitney results for TPC Item 14.

**Table 8**
*TPC Item 8 - Treatment Group and Control Group Team Interaction*

| Treatment (*n*) | Control (*n*) | Diff. Est. | Test Stat. | P-value |
|---|---|---|---|---|
| 20 | 17 | 1 | 396 | 0.0226 |

**Table 9**
*TPC Items 11 and 14 - Treatment Pretest and Posttest Team Interaction*

| TPC Item # | Pre-Treatment (*n*) | Post-Treatment (*n*) | Diff. Est. | Test Stat. | P-value |
|---|---|---|---|---|---|
| 11 | 21 | 20 | -0.5 | 363 | 0.025 |
| 14 | 21 | 20 | 1 | 541.5 | 0.0039 |

Kruskall-Wallis results identified that Items 1, 3, 8, 13, and 21 (see Appendix A) exhibit statistically significant differences between outcome teaming knowledge formation between the treatment and control groups. Item 13 also shows a statistically significant difference between outcome teaming knowledge formation between the pretest and posttest of the treatment groups. TKT Item 1 addressed appropriate action when a disagreement occurs in a group: “When there is a disagreement or difference of opinion in your team, it is generally best to…”. Table 10 (next page) displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 1.

**Table 10**
*TKT Item 1 - Treatment Group and Control Group Knowledge Formation*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Treatment | 17 | 1 | 1 | 22.075 | 6.904716 | 0.0086 |
| Control | 20 | 1 | 1 | 15.382353 | | |

TKT Item 3 questions actions or responses to the unpreparedness of group leadership: "Your team leader comes to your scheduled meeting without an agenda. What should you do?" Table 11 displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 3.

**Table 11**
*TKT Item 3 - Treatment Group and Control Group Knowledge Formation*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Treatment | 17 | 1 | 1 | 21.65 | 4.7210083 | 0.0298 |
| Control | 20 | 1 | 1 | 21.65 | | |

TKT Item 8 addresses the review of peer groups' work: "You have been asked to review another team's process check. Which of the following would be the best response?" Table 12 displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 8.

**Table 12**
*TKT Item 8 - Treatment Group and Control Group Knowledge Formation*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Treatment | 17 | 1 | 1 | 21.575 | 4.7210083 | 0.0207 |
| Control | 20 | 1 | 1 | 15.970589 | | |

TKT Item 11 is designed to identify productive actions when angry in a group setting: “You have gotten quite angry in a team meeting. Which of the following is the least productive thing you could do?” Table 13 (next page) displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 11.

**Table 13**
*TKT Item 11 - Treatment Group and Control Group Knowledge Formation*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Treatment | 17 | 1 | 1 | 21.875 | 4.0859523 | 0.0432 |
| Control | 20 | 1 | 0 | 15.617647 | | |

TKT Item 13 questions about strategies to engage removed members of the team: “The opinions of quiet members of a team are often not heard. If you were meeting leader, what would you do about it?” Table 14 displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 13.

**Table 14**
*TKT Item 13 - Treatment Group and Control Group Knowledge Formation*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Treatment | 17 | 1 | 1 | 22.6 | 6.653262 | 0.0099 |
| Control | 20 | 1 | 0 | 14.764706 | | |

TKT Item 21 questions about action that lead to problem resolution after disagreements among team members: “Two members of your team have a genuine disagreement (not just miscommunication or personality conflict). Which of the following would be most likely to lead to a resolution?” Table 15 (next page) displays the treatment group and control group Kruskall-Wallis supplemental results for TKT Item 21.

**Table 15**
*TKT Item 21 - Treatment Group and Control Group Knowledge Formation*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Treatment | 17 | 1 | 1 | 21.575 | 5.349076 | 0.0207 |
| Control | 20 | 1 | | 15.970589 | | |

Again, TKT Item 11 is designed to identify productive actions when angry in a group setting. Table 16 displays the treatment group pretest and posttest Kruskall-Wallis supplemental results for TKT Item 11.

**Table 16**
*TKT Item 11 - Treatment Pretest and Posttest Group Knowledge Formation*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Pre-Treatment | 17 | 1 | 0 | 17.880953 | 4.0859523 | 0.0432 |
| Post-Treatment | 20 | 1 | 1 | 24.275 | | |

As previously described, TKT Item 13 questions about strategies to engage removed members of the team. Table 17 displays the treatment group pretest and posttest Kruskall-Wallis supplemental results for TKT Item 13.

**Table 17**
*TKT Item 13 - Treatment Pretest and Posttest Group Knowledge Formation*

| Group | *n* | DF | Median | Avg. Rank | Chi Square | P-value |
|---|---|---|---|---|---|---|
| Pre-Treatment | 21 | 1 | 0 | 16.428572 | 9.002198 | 0.0027 |
| Post-Treatment | 20 | 1 | 1 | 25.8 | | |

**Discussion and Conclusions**

Given the significant results for this sample, using the TPC and TKT instruments, several conclusions can be made. Considering the Palit and Stein study (2008), it was determined that the inclusion of specific instruction on the use of relevant information and multimedia communication technologies as a component of the treatment has definite potential to influence associated team-based knowledge. The flexibility that collaborative teaming technologies permits allows for a heightened level of shared group knowledge that extends beyond the task at hand (Abbott, 1998). Secondly, in this study involving knowledge formation between groups, students exhibited progression in functioning in a team structure. However, incorporating collaborative information and multimedia technologies did not enhance team interaction. Supplementary to the primary investigation, this study identified differences in treatment and control groups, as well as pretests and posttests, that relate to a lack of understanding and acceptance in handling conflicts, group planning, and overall review and evaluation of group work at the undergraduate level within technology education.

While information and multimedia technology can be considered useful for group collaboration and communication, as this study identified, it is limited by the level of interactivity and the amount of control of group dynamic when using collaborative tools. Teacher education programs must heavily consider direct student knowledge, as well as group qualities and characteristics, to create functional team dynamics through the successful introduction of multimedia team-based integrative technologies. Preservice teacher knowledge of exemplar team structure and function is invaluable, considering that the information can be transferred into direct classroom practice to enhance learner experience. In conclusion, teaming is a pivotal skill and knowledgebase for future educators, as effective inclusion of teacher applications and 21st century skills integration are no longer considered exceptional teacher practice, but are now among minimal expectations for all teachers.

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## Appendix A:
## TKT items

*TKT items exhibiting a statistically significant difference*

| | |
|---|---|
| TKT item 1: | When there is a disagreement or difference of opinion in your team, it is generally best to<br>a. find some way to downplay it so as not to draw attention to it.<br>b. address the disagreement directly and supportively, even if there is a risk of conflict.<br>c. try to ignore it altogether.<br>d. point out that dissention is harmful to a team. |
| TKT item 3: | Your team leader comes to your scheduled meeting without an agenda. What should you do?<br>a. Make your first agenda item developing an agenda as a team.<br>b. Let the meeting proceed without an agenda.<br>c. Tell the team leader to write out an agenda right now and take the rest of the team for coffee until s/he is done.<br>d. Suggest the meeting be postponed until the team leader gets his act together. |
| TKT item 8: | You have been asked to review another team's process check. Which of the following would be the best response.<br>a. All excellent ratings, because that would show they know what they are doing.<br>b. Excellent ratings on task-related questions; the touchy-feely questions don't matter.<br>c. Excellent ratings on the touchy-feely questions, because if they got their processes correct, task excellence is sure to follow.<br>d. A variety of responses, some high and some low, because that would give pointers to improvement. |
| TKT item 13: | The opinions of quiet members of a team are often not heard. If you were meeting leader, what would you do about it?<br>a. Set up a specific order for everyone to speak and then follow it.<br>b. Leave it be. If they don't want to talk, they shouldn't have to.<br>c. Ask them to adopt roles in the meetings, such as time-keeper and facilitator.<br>d. Ask them to write down their positions and give it to you anonymously after the meeting. |

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| TKT item 21: | Two members of your team have a genuine disagreement (not just miscommunication or personality conflict). Which of the following would be most likely to lead to a resolution?<br>a. Ask questions to try to understand each person's position and look for solutions that both might like.<br>b. Ask each person to give up something.<br>c. Have the other team members come up with a third position they can agree on.<br>d. Take a vote among all the team members—winner takes all. |