*Federation of Business Disciplines Journal*

Volume 12, 2022 16-29

**IMPROVING ANALYTICAL AND CRITICAL THINKING SKILLS WITH**

**TECHNOLOGY MEDIATED LEARNING**

**Marianna M. Rexer**

*Wilkes University*

Wilkes-Barre, PA 18766

USA

Anuradha C. Ghai

*Wilkes University*

Wilkes-Barre, PA 18766

USA

**ABSTRACT**

Analytical problem-solving skills and critical thinking skills are atop the list of abilities desired by employers. Professors are always striving to help students improve these skills and now technology may be able to help. Technology-Mediated Learning (TML) software has become more versatile in its capabilities and may help students develop processing skills in addition to their development of content knowledge. This study finds using TML software in the classroom increased student scores in the critical thinking steps of applying knowledge, and synthesizing information in formulating conclusions when the assigned homework had immediate feedback and an unlimited number of attempts.

**Keywords:**accounting education, analytical problem solving, critical thinking, Technology-mediated learning

**INTRODUCTION**

Managers across industries seek a specific set of skills in new hires, and each year surveys ask employers for a list of those desired skills. The 2020 Workplace Learning Report by LinkedIn found that rapidly changing technology is pushing the increased need for analytical skills so new professionals can fuel the company’s growth (LinkedIn, 2021). Analytical skills consist of a variety of categories including: analytical problem solving, critical thinking, communication, data analysis and creativity.  While employers are looking for professionals with various analytical skills, 56 percent of managers reported new graduates lack both analytical problem-solving, and critical thinking skills ( (Bauer-Wolf, 2018)). This is not new as Reinstein and Bayou ( (1997)) have shown managers who utilize these skills make better decisions that those who do not.

Analytical problem solving is the process of deconstructing information into smaller categories, recognizing patterns, and making a conclusion. It is a problem solving process emphasizing an understanding of underlying components. Critical thinking is the ability to apply data from various sources, make inferences based on that data, evaluate various courses of action, and synthesize the information to make a decision. It is analytical problem solving plus the ability to make inferences based on all known information.  A person simply understanding a subject is a necessary, but not a sufficient, condition for that person to engage in analytical or critical thought. Educators understand the importance of these skills and their attempts to teach them to their students are met with varying degrees of success. Analytical problem solving can be improved by providing a wide set of topics (Sharma, 1997) and certain information processes and learning environments do encourage critical thinking (Cascini & Rich, 2007; Ennis, 2011; Turner, 2011).  For example, critical reflection and peer review increased analytical problem solving (Larsen & Gardebo, 2017) and active learners can be introduced to the critical thinking process in class and participate in critical thinking after the class ends (Lynch & Wolcott, 1997). Analytical problem solving and critical thinking are necessary skills for accountants who use available information to evaluate the accuracy of financial reports. To explore these issues, first, analytical problem solving and critical thinking in education are examined. Second, hypotheses are developed and tested. Finally, conclusions are drawn.

**LITERATURE REVIEW**

 The accounting profession has always required practitioners master the knowledge competencies in accounting (Thompson & Washington, 2015). However Albrecht et al (1994) states the mastery of concept competencies such as oral and written communication, listening skills, team and leadership skills, conflict resolution, analytical problem solving, and critical thinking are also considered as a vital part of the accountant’s skill portfolio. Mastery of these soft skills enable accounting leaders to create, identify, evaluate, and use both knowledge and opportunities (Greene & Yu, 2015).

All accountants need the ability to gather and interpret complex financial data, analyze results, and communicate findings to the stakeholders. Accounting.com’s survey indicated the top two skills for accountants are: analytical problem solving, and critical thinking (Accounting.com, 2021). Analytical problem solving is utilizing a process to gather, organize, and detect patterns when confronted with complicated issues. The result of analytical problem solving is noisy data is turned into information. Critical thinking is making informed decisions based on the application and synthesis of the data. Given the need for both analytical and critical thinking skills in our global work environment, there have been many suggestions for enhancement and/or change in the educational environment; especially at the university level.

**Analytical Problem Solving and Critical Thinking**

Understanding, analyzing and making conclusions from complex information is a life-long skill desired by professionals. Unfortunately, students often struggle to understand various pieces of information and are unable to complete essential tasks, such as gathering, identifying, and comprehending information. Analytical problem solving is the process of breaking down information into smaller, identifiable parts and is the skill necessary for these students. While critical thinking is more holistic as it applies data from analytical problem solving and synthesizes various sources of information; analytical problem solving is a key thinking skill and a necessary step in the critical thinking process (Lakeh & Ghaffarzadegan, 2015).

Critical thinking begins with the pieces of information gathered in the analytical problem solving process, applying all knowledge, and synthesizing it in developing solutions. It is a necessary prerequisite and corequisite of effective learning, thinking, and problem solving (Shakirova, 2007). Youki Terada (2018) states that “strategies that target students’ metacognition – the ability to think about thinking – can close a gap that some students experience between how prepared they feel… and how prepared they actually are.” In other words, critical thinking skills enhance learning.  Professors are urged to incorporate analytical problem solving and critical thinking skills by providing tasks that encourage thinking beyond simple calculations and also consider the possibility of more than one solution (Smith, 2014) (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956).

Various analytical problem solving, and critical thinking strategies should be woven into teaching modalities and, as approaches to developing these skills advance with time; so should integration into the students’ education.   The same is true for utilizing technology in the education. As educational technology advances, more advanced approaches should be woven into teaching modalities. Integrating analytical problem solving and critical thinking with technology can assist students to further develop their competencies.

Educators generally refer to Bloom’s Taxonomy when discussing analytical and critical thinking (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956).  The original taxonomy was revised in 2001 and the Anderson, et al. (2013) revision emphasizes the importance of dynamic processes instead of the original static educational objectives.   Bloom separated how people learn into three domains and the one that emphasizes intellectual outcomes is the cognitive domain. This domain begins with knowledge and progresses through the person’s ability to process information, apply knowledge to actual situations, and synthesize or rearrange components to see how they are organized and relate to each other in developing new ideas. The importance of teaching and nurturing analytical and critical thinking is emphasized in meta-analyses of research. Huber and Kuncel (2016) found significant gains in analytical and critical thinking from the college experience in general.  However they suggest that research is needed on teaching critical thinking within specific academic disciplines. The Abrami et al. (2015) meta-analysis emphasized that the discipline-specific analytical and critical thinking exercises showed more promise as effective learning strategies.

**Cognitive Domain**

The cognitive domain involves the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses.  It is further divided into subsets and progresses from simpler to more complex difficulties. Bloom’s cognitive domain begins with factual knowledge or basic information (1956).  As students learn, the information becomes pieces of a larger structure that relates together to provide conceptual knowledge.  Then, by looking into these relationships, students understand how to make their knowledge more complete. This provides the procedural knowledge of how to do a task or solve a problem.

 Analytical problem solving is this process of acquiring knowledge and understanding through thought, and experience. It is a stepwise process and matches student learning.  Solving simple problems occurs before solving more complex problems.  With experience, students learn additional information that assists them in learning to solve increasingly complicated problems. As such, self-efficacy is positively related to cognitive and metacognitive learning strategies (Sun, Xie, & Anderman, 2018).

 Professors can help students in the cognitive phase by teaching the analytical problem solving process and helping students break down the problem into smaller, more relevant components (Zohar & David, 2009).

**Metacognitive Domain**

Anderson et al’s revision of Bloom’s taxonomy (2013) expanded its emphasis to the process that occurs after the procedural knowledge is obtained. Going beyond the technical skills is a metacognitive process (Saxton, Belanger, & Becker, 2012). Metacognitive knowledge is a large part of the revised taxonomy and is the students’ awareness of their own thought processes. Simply stated, it is the ability to think about thinking and is a partial generator of critical thinking. “Awareness of one’s process must precede the critical analysis for problem resolution” (Hanley, 1995).

 Fogarty (1994) described the metacognition process as having three distinct phases:

1.  Development of a plan of action

2.  Maintenance of student understanding and development of alternative strategies

3.  Evaluation of the plan after completing the task.

Professors can help students in the metacognitive phase by showing how to apply all the information available in developing potential solutions (Zohar & David, 2009).

**Epistemic Cognition**

Providing a variety of problems increases a students’ Epistemic Cognition which is the “process involving dispositions, beliefs, and skills regarding how individuals determine what they actually know, versus what they believe, doubt, or distrust” (Greene & Yu, 2015). Professors, looking at measuring students’ skills in a specific area, can increase those skills by assigning various types of problems. Some problems can involve a straight forward process while some can require a student to do various calculations to find missing information. Students may feel they understand a topic and by assigning more than easy to solve, step by step problems; students realize more details about what they know and what they do not know.

Students learn to apply and synthesize complex information requiring them to continually evaluate of the quality of evidence when provided with a variety of problems and feedback (King & Kitchener, Developing Reflective Judgment: Understanding and Promoting INtellectual Growth and Critical Thinking in Adolescents and Adults, 1994). The more adept students become at evaluating, applying, and synthesizing information; the more they increase their ability to reevaluate and revise their actions based on new information (King & Kitchener, 2002).

Professors can help students in the epistemic phase by providing relevant and timely feedback that helps them understand where they are correct and where they need further work. (Zohar & David, 2009)

**Technology-Mediated Learning**

 Increasing epistemic cognition is similar to corrective feedback in its ability for students to learn what they know, doubt, and don’t know. Corrective feedback is described by Lightbown and Spada (2003) as an indication to a learner that the answer is incorrect (p.172). Implicit, corrective feedback through repetition, clarification & recasted problems, allows learners to notice their errors and correct them (Dekeyser, 1993) as well as earning higher test scores (Havranek, 2002).

 Requiring students solve the same types of problems repeatedly has proved inadequate as learners need different types of learning experiences (Peterson & Walberg, 1979). Students need opportunities to learn to solve problems by constructing their understanding of the problem and the solution. Constructing one’s own understandings, rather than simply following a professor’s solution, requires students to question their assumptions, generate and explore their own models, and build solutions that organize their experiences (Duffy & Jonassen, 1992). “In short, learners construct their knowledge rather than just receive it” (Springer & Borthick, 2004).

When students repeat the same problem with the same data, they may not be remembering the process but remember the numbers used in each formula. Technology-mediated -earning (TML) is an umbrella term for using various technology in learning and teaching. The usage of TML is increasing in managed learning environments where professors set the parameters, and one TML tool is software designed to allow students to repeat problems with a different set of numbers on each attempt. Assigning various style problems and allowing repeated attempts with different numbers ensures the student focuses on the processes and not the numbers. Assigning a variety of homework problems utilizing TML allows students to work at their own pace and provides a different learning experience. Corrective feedback with TML showed greater success in problem solving in science tasks (Lamb & Premo, 2015). Allowing the student to receive feedback after each attempt allows the student to immediately recognize an error and provides the opportunity to build a better solution.

**Accounting Students and TML**

In accounting education, students need to comprehend the information available as well as comprehend the missing information needed to solve a problem.  Even simple accounting questions cannot be answered until students have all the information necessary. They need analytical problem solving skills to gather, organize, and process information. They also need critical thinking skills to apply and synthesize the information.

 Relating Fogarty’s critical thinking development process to accounting majors involves developing a plan that allows for students to make their own mistakes and identify those mistakes. This educational process should provide the student with practice solving a variety of problem types and involve instant feedback in time to reflect on their learning.  Providing a variety of problems gives students the opportunity to generalize and derive meaning across situations and then readjust and reevaluate.

Providing a variety of problem types, encourages students to look at the same issue in a variety of ways. This process helps identify the problem so it can be better understood and leads to better critical thinking, analysis, and decision making (Opitz, Ferdinand, & Mecklinger, 2011). The variety of problems selected should be enough to allow students to realize which parts of the problem solving process they know and don’t know.

The variety of problems can also include varying the data included in the problem. Setting the TML to provide students with a unique set of numbers each time they work on the problem, forces them to understand the process themselves and not the numbers. Assessments individualized for each student combined with feedback increased critical thinking skills in students (Turner, 2011).

The timing in which a student receives feedback is also important (Mullet, Butler, Verdin, von Borries, & Marsh, 2014). Providing instant feedback informs students of their errors and allows them to review their work while they still remembering their thought process. There is benefit to receiving both immediate and delayed feedback although students receiving immediate feedback are less likely to form a memory of an incorrect concept (Crouch & Mazur, 2001). And, in courses that progressively build on earlier concepts, the memory of an incorrect concept may irreversibly impair the student’s understanding of the newer topic (Dihoff, Brosvic, & Epstein, 2003). Therefore student’s understanding is at risk if a misconception is not quickly identified and corrected (Crouch & Mazur, 2001).

Some TML options provide immediate feedback to students and can range from letting the student know the answer was incorrect to providing them with the solution. Other options can also provide each student with a predetermined number of attempts, and a set of numbers that differs from prior question attempts and from other students. While this study used the TML developed by John Wiley & Sons, McGraw Hill, and many other learning companies have their own versions of TML. The success of using a TML to have the student interact with different contexts, receiving feedback, and allow for repetition in training has been established (Shield, 2016).

The reviewed literature indicates that combining TML and immediate feedback may increase analytical problem solving and critical thinking skills.  Therefore, the research hypotheses relating to the effectiveness of TML are as follows:

**H1**:  Students assigned a variety of TML assignments with instant feedback will have a higher increase in their analytical problem-solving scores than students who do not use TML.

**H2**:  Students assigned a variety of TML assignments with instant feedback will have a higher increase in their critical thinking scores than students who do not use TML.

**METHODOLOGY**

 This study analyzes the impact of TML from Wiley Plus on analytical problem solving and critical thinking skills in the second course of a two course intermediate accounting sequence.  Each student was required to complete two in-class, graded assignments requiring 1) preparation of the cash flow statement, 2) ratio analysis, and 3) a conclusion regarding the financial health of a company. These assignments were given at the beginning and the end of the term and based on both the analytical problem solving skills assessment by Ad’hiya and Laksono (2018) and the critical thinking skills assessment designed by accounting educators (Cascini & Rich, 2007; Lynch & Wolcott, 1997).

 The professor was the same for each course offering and while only the dollar amounts of the assessment measures were changed, the assignments and exams were the same. What changed was the modality in which the homework was submitted. During the first year, the classes were in a face to face format and the homework was completed and submitted manually.  During the second year, the classes were face to face and the students selected if they wanted to complete the homework manually and submitted it electronically, or use TML. Classes were hybrid during the third year and students again had the choice of completing the homework manually and submitting it electronically, or using TML.  In the fourth year, the classes were completely online and the homework was completed using TML.

 The sample consisted of 131 business students attending a private university and enrolled in one of the course modalities as shown in Table 1.  The instrumentation was a required assignments and thus nonresponse was not a research issue. The sample was almost evenly split by gender (49.62 percent males; 50.38 percent females) and major (accounting and/or finance).  In terms of class year 94.66 percent were juniors and 5.34 percent were seniors. The students ranged in age from 19 – 22.

 As shown in Table 1, there were 65 students enrolled in the face-to-face classes, 26 in the hybrid classes, and 40 in the online classes. There were 50 students who completed the homework manually, and 80 who used TML.  The TML was set to immediately provide students with a grade for each problem upon submission but without any further details. Students were able to resubmit their homework as many times as necessary to achieve their desired grade and the TML was also set so each subsequent attempt contained different set of numbers.

**Table 1**

**Class type and Homework Submission Modality**

|  |  |  |
| --- | --- | --- |
|  |  | Homework Submission by Modality |
| **Class type** | **Number of students** | **Manual** | **Electronic (non-TML)** | **TML** |
| In person | 65 | 34 | 6 | 25 |
| Hybrid | 26 | 0 | 11 | 15 |
| Online | 40 | 0 | 0 | 40 |

 The initial assessment of students’ analytical problem solving and critical thinking skills involved the preparation of a cash flow statement, various ratios, and a conclusion about the company’s financial health in an Intermediate Accounting Course.  The prerequisite course for this class was managerial accounting where a course module focused on preparing the basic cash flow statement. At the start of the term, students were asked to complete a graded in-class assignment to assess the retention of information from the prerequisite class.  After grading was complete, the assignment results were reviewed in class and students were informed they would have a similar assignment at the end of the term. At the end of the semester, a second graded in-class assignment, similar to the first, was completed.  Students also completed surveys which included demographic information immediately after submitting the second assignment.

 Similar to the analytical problem skill assessment by Ad’hiya and Laksono (2018) and the critical thinking skill assessment of Cascini and Rich (2007); students were informed they were being assessed on the three sub-parts of the problem: the cash flow statement, corporate analysis, and conclusions regarding the company’s financial health. Students were aware they needed to show their work and that points were assigned to each step of the solution.  For both assignments, students were graded on analytical problem-solving skills illustrated by their ability to break the material into smaller pieces and their ability to solve the required step by step processes. They were also graded on their critical thinking skills which included applying information from various sources and synthesizing the information to solve the problem and answer the required questions.

 The analytical problem solving and critical thinking process encompasses several stages; and as students may have varying levels of skills in each stages, their analytical problem solving and critical thinking skills were measured in multiple areas. Therefore; while students received only an assignment grade, their analytical and critical thinking abilities were assessed in multiple areas.

 Analytical problem solving skills are part of the cognitive domain and students were assessed on their knowledge and comprehension of the process used to prepare a statement of cash flow. Students were evaluated on their ability to process vital questions and break down the material into the necessary parts to complete the required problem.  Did they have knowledge and comprehension of the cash flow statement, its preparation process, and the requested analysis? In the analysis, this stage is referred to as “process.”

 Critical thinking skills are part of the metacognitive and epistemic domains. Students may develop some metacognitive skills before or after developing some epistemic cognition skills; and therefore, both stages were assessed independently. To assess some of the students’ abilities in the metacognitive domain, students were evaluated on their ability to apply, analyze, and interpret information.   Did they apply data from various sources, make inferences based on that data, and interpret the information to make general conclusions? In the analysis, this stage is referred as “application.”

 To assess some of the students’ abilities in the epistemic domain, students were gaged on their ability to develop solutions and conclusions about the company.  Did they synthesize all available information, and evaluate the quality of information when evaluating the company’s financial health? In the analysis, this stage is referred to as “synthesis.”

 When analyzing the process, application, and synthesis stages, scoring was based on the presences of specific steps or items necessary to complete the assignment. The items present, partially present, or not present were encompassed in a score indicating the skills were:

1 = Not demonstrated

2 = emergent skills

3 = evident skills

**RESULTS**

**Descriptive Statistics**

The study aimed to determine the possible influence of TML on students’ analytical problem solving and critical thinking skills. For each pre and post-test, students’ analytical problem solving skills were measured with a process score that analyzed the knowledge and comprehension stages. Their critical thinking skills were measured with an application score encompassing the application & analysis stages and a synthesis score encompassing the synthesis and evaluation stages. The number of students scoring in each modality, by skill level, for the pre and post-test are shown in Table 2.

The change in the students’ skills is represented by the difference between the students’ pre-test and post-test scores. In order to draw conclusions about the change in students’ skill scores, other variables need to be ruled out. Correlations between external factors and the change in scores were computed and the results are shown in Table 3. On the demographic survey, data was collected to measure the independent variables of age, gender, ethnicity, grade level, major, and employment level, The survey also collected information on student experiences and perceptions of TML as well as their perception of these software benefits: purchasing at a lower price as compared to traditional text book prices, learning through repetition, submitting homework online, seeing solution hints while completing homework, and receiving immediate feedback. There were no significant correlations found between the demographic data and both the students’ analytical problem solving score or their critical thinking scores.

In addition, the results indicate there was no correlation between demographics and either the change in analytical or critical thinking scores**,** no correlation between students who used TML and the change in analytical or critical thinking scores, and no correlation between students who thought the TML increased their scores and the change in scores.

**Table 2**

**Number of Students with scores per Homework Modality and Assessed Skill Level**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Homework Submission Modality and Assessed Skill Level | Pre-Score Knowledge & Comprehension(Analytical problem solving) | Post-Score Knowledge & Comprehension (Analytical problem solving) | Pre-score Application & Analysis (Critical Thinking) | Post-score Application & Analysis (Critical Thinking) | Pre-score Synthesis & Analysis (Critical Thinking) | Post-score Synthesis & Analysis (Critical Thinking) |
| Manual Homework |  |  |  |  |  |  |
| 1 Not Demonstrated | 50 | 2 | 37 | 3 | 32 | 2 |
| 2 Emergent | 40 | 31 | 54 | 44 | 58 | 28 |
| 3 Skillful  | 1 | 58 | 0 | 44 | 1 | 61 |
|  |  |  |  |  |  |  |
| TML Homework |  |  |  |  |  |  |
| 1 Not Demonstrated | 25 | 0 | 22 | 0 | 22 | 0 |
| 2 Emergent | 14 | 16 | 18 | 18 | 17 | 12 |
| 3 Skillful  | 1 | 24 | 0 | 22 | 1 | 28 |

**Table 3**

**Correlation between Demographic Factor and Change in Students’ Scores**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Demographic factor | range low | range high | mean | correlation coefficientAnalytical problem solving Scores | correlation coefficient Critical Thinking Scores |
| TML helps learning (Likert 1-5 scale) | 1 | 3 | 2.35 | -0.0996 | -0.0052 |
| Lower cost is a benefit of the software | no = 0 | yes = 1 | 0.27 | 0.1120 | 0.1187 |
| Learning through repetition is a software benefits | no = 0 | yes = 1 | 0.51 | -0.0080 | -0.1135 |
| Submitting homework online is a software benefit | no = 0 | yes = 1 | 0.66 | 0.0186 | 0.1890 |
| Solution hints are a benefit of software | no = 0 | yes = 1 | 0.27 | 0.1087 | -0.0133 |
| Increased confidence in subject is a software benefit | no = 0 | yes = 1 | 0.66 | 0.1118 | -0.1051 |
| Immediate feedback is a software benefit | no = 0 | yes = 1 | 0.76 | 0.1269 | .1321 |
| Perception of electronic texts (Likert 1-5 Scale) | 1 | 5 | 3.15 | 0.0306 | -0.0172 |
| Gender  | 49.62% male | 50.38% female | NA | -0.1365 | -0.1282 |
| Age Range  |  |  |  | 0.0329 | 0.0535 |
|      18-22 | N=74 | 56.49% | NA |  |  |
|      23-27 | N=28 | 21.37% | NA |  |  |
|      28-32 | N=24 | 18.32% | NA |  |  |
| Ethnicity origin or race |  |  |  | 0.0141 | 0.0109 |
|      Asian or Pacific Islander | N=15 | 11.45% | NA |  |  |
|      Hispanic | N=32 | 24.43% | NA |  |  |
|      White | N=84 | 64.12% | NA |  |  |

The pre and post scores were tested with the student’s t-test and the analysis is shown in Table 4. The significant increase in scores for each area: process, application, & synthesis indicates students are learning skills in the classroom and further analysis is needed to determine if any is associated with TML.

**Table 4**

**Pre and Post T-test scores by Stage**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Process(Analytical problem solving) | Application (Critical Thinking) | Synthesis (Critical Thinking) |
| Difference | -1.168 | -0.931 | -1.061 |
| t (Observed value) | -18.029 | -14.410 | -16.721 |
| |t| (Critical value) | 1.969 | 1.969 | 1.969 |
| DF | 260 | 260 | 260 |
| p-value (Two-tailed) | < 0.0001 | < 0.0001 | < 0.0001 |
| alpha | 0.05 | 0.05 | 0.05 |

In the process, application, and synthesis areas, the change in the students’ skills is the difference between the students’ pre-test and post-test scores and is an interval variable. Analyzing an interval variable with the dichotomous variable representing students who either did or did not use TML requires point-biserial correlation.  The point-biserial correlation is a special case of the Pearson r. It is a correlation coefficient used to measure the strength and direction of the association that exists between an interval variable and a dichotomous one.

Table 5 illustrates the point-biserial correlation results for each of the categories: process, application, and synthesis. As shown in Table 5, analytical problem solving as measured by the students ability to process the required steps has a p-value of 0.141. This indicates students using TML did not improve their analytical problem-solving scores more than students who did not use TML. As discussed in the literature, analytical problem solving is the ability to process information in a step wise method. Since students’ scores increased significantly as shown in Table 4, and there is not an association with TML usage, the scores must have increased due to other influences in the classrooms.

**Table 5**

**Point-biserial Correlation of TML Use and Change in Score**

|  |  |  |
| --- | --- | --- |
| Stages | R | p-values |
| Process (Analytical problem solving) | -0.116 | 0.141 |
| Application (Critical Thinking) | **-0.240** | 0.009 |
| Synthesis (Critical Thinking) | **-0.223** | 0.010 |
| Values in bold are different from 0 with a significance level alpha=0.05 |

In the two categories associated with critical thinking, there is a significant association between students using TML and an increase in scores. With respect to the student scores in the application area, the p-value of .009 indicates students using TML significantly increased their ability to apply, analyze, and interpret information. Likewise, the p-value of 0.010 for synthesis indicates TML has a significant impact on the student’s ability to synthesize all available information and evaluate the quality of information when completing the assigned problem.

**DISCUSSION**

**Future research**

As correlation coefficient for the process stage shows in Table 5, the impact of TML does not influence the analytical problem-solving skills which includes gathering and interpreting information.  The data indicates the professor’s teaching of the process steps were incorporated by all students and future research can examine if using TML helps students process these steps more quickly than those who do not. For example: does understanding the process steps more quickly allows students to focus on the critical thinking steps of application and synthesis?

Students who learn analytical problem solving more quickly, have more time to focus on the application and synthesis steps which may, in turn, increase their critical thinking skills.  Future research questions to address include the following: What factors encourage students to spend more time in the process, application, or synthesis stage?

Table 5 also shows the positive impact of TML on the students’ ability to apply acquired knowledge and synthesize the information when forming conclusions. Future research can determine if there is a larger change in critical thinking score based on the type or array of TML problems assigned to students: multi-step problems, drop down box questions, multiple choice questions, etc. Or are students’ influenced more by one type of TML over another?

**Conclusion**

Problem solving consists of three steps. The analytical problem-solving stage of gathering and processing data and the two critical thinking stages of analyzing the data, and synthesizing the data in developing solutions. As the accounting profession demands new accountants possess analytical problem solving and critical thinking skills; the quality of future accountants can be impacted by the ability of students to learn and apply these skills in the classroom and their future workplace.

We explored the connection between students’ use of TML and an increase in analytical problem solving, and an increase in their critical thinking skills, and found using TML improved students’ ability to think critically when analyzing information and synthesizing the data when developing conclusions.

**REFERENCES**

Abrami, P.C., R. M. Bernard, E. Borokhovski, D. I. Waddington, C. A. Wade, and T. Person. 2015. Strategies from teaching students to think critically: A meta-analysis.

*Review of Educational Research 86 (2) 431-468. doi:10.3102%2F0034654314551063*

Albrecht, W. S., D. Clark, J. Smith, K. Stocks, and L. Woodfield. 1994. An accounting curriculum for the next century. *Issues in Accounting Education* 9 (2): 401-425.

Anderson, L. W., D. R. Krathwohl, P. W. Airasian, K. A. Cruikshank, R. E. Mayer, P. R. Pintrich, and M. Wittrock.  2013. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, Abridged.* Boston: Pearson Education Group.

Bauer-Wolf, J. 2018. *Overconfident Students, Dubious Employers*. Retrieved from InsideHigherEd.com: https://www.insidehighered.com/news/2018/02/23/study-students-believe-they-are-prepared-workplace-employers-disagree

Bloom, B., M. Englehart, E. Furst, W. Hill, and, D. Krathwohl. 1956. *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain.* New York, Toronto: Longmans, Green.

Cascini, K., and Rich, A. J. 2007. Developing Critical Thinking Skills in the Intermediate Accounting Class: Using Simulations with. *Journal of Business Case Studies*, 17-28. doi:10.19030/jbcs.v3i2.4839

Dekeyser, R. M. 1993. The effect of error correction on L2 grammar knowledge and oral proficiency. *The Modern Language Journal, 77(4), 501-514. doi:10.1111/j.1540-4781.1993.tb01999.x*

Duffy, T.M., and D. H. Jonassen, eds. 1992. *Constructivism and the Teaching of Instruction: A Conversation.* Hillsdale, NJ: Erlbaum.

Ennis, R. H. 2011. *The Nature of Critical Thinking: An Outline of Critical Thinking Dispositions and Abilities.* Available at:

https://education.illinois.edu/docs/default-source/faculty-documents/robert-ennis/thenatureofcriticalthinking\_51711\_000.pdf?sfvrsn=7bb51288\_2

Fogarty, R. 1994. *The Mindful School: How to Teach for Metacognition.* Illinois: IRI Skylight.

Greene, J. A., and S. B. Yu. 2015. Educating critical thinkers: The role of epistemic cognition. *Policy Insights from the Behavioral and Brain Sciences*, 3(1) 45-53. doi:10.1177%2F2372732215622223

Hanley, G. L. 1995. Teaching critical thinking: Focusing on metacognitive skills and problem solving. *Teaching of Psychology*, 68-72. doi:10.1207/s15328023top2201\_21

Havranek, G. 2002. When is corrective feedback most likely to succeed? *International Journal of Educational Research, 37(3), 255-270.* *doi:10.1016/S0883-0355(03)00004-1*

Huber, C.R. and N. Kuncel. 2016. Does college teach critical thinking? A meta-analysis. *Review of Educational Research.* 86 (2), 431-468. doi:10.3102%2F0034654315605917

King, P. M. & K. Kitchener. 1994. Developing Reflective Judgment: Understanding and Promoting Intellectual Growth and Critical Thinking in Adolescents and Adults. *San Francisco: Jossey-Bass*.

King, P. M. & K. Kitchener. 2002. The reflective judgment model: Twenty years of research on epistemic cognition. *In Hofer, B. K., and Pintrich, P. R. (eds.),*Personal Epistemology: The Psychology of Beliefs About Knowledge and Knowing*, Erlbaum, Mahwah, NJ*.

Lamb, R., and J. Premo. 2015. Computational modeling of teaching and learning through application of evolutionary algorithms. *Computation* 427-443. doi:10.3390/computation3030427

Lightbown, P., & Spada, N. 2003. How languages are learned (Rev. ed*.). Oxford, UK: Oxford University Press*

LinkedIn Learning. 2020. *2020 Workplace Learning Report*. Retrieved from https://learning.linkedin.com/content/dam/me/learning/resources/pdfs/LinkedIn-Learning-2020-Workplace-Learning-Report.pdf

Lynch, C. L. and S. K. Wolcott. 1997. Critical thinking in the accounting classroom: A reflective judgment developmental process perspective. *Accounting Education: A Journal of Theory, Practice and Research*, 59-78.

Opitz, B., N. K. Ferdinand, and A. Mecklinger. 2011. Timing matters: The impact of immediate and delayed feedback on artificial language learning. *Frontiers in Human Neuroscience,* 5-8. doi:10.3389/fnhum.2011.00008

Peterson, P.L., and H. J. Walberg, eds. 1979. *Research in Teaching: Concepts, Findings, and Implications.*  Berkeley, CA: McCutchan.

Reinstein, A., and M.E. Bayou. 1997. Critical thinking in accounting education: processes, skills and applications. *Managerial Auditing Journal* 336-342.

Shakirova, D.M. 2007. Technology for the shaping of college students' and upper-grade school students' critical thinking. *Russian Education and Society.* 49 (9) 42-52. doi:10.2753/RES1060-9393490905

Springer, C. M. and A. F. Borthick. *2004*. Business Simulation to Stage Critical Thinking in Introductory Accounting: Rationale, Design, and Implementation. *Issues in Accounting Education*. 19 (3) 277-303.

Sun, Z., Xie, K., & Anderman, L. H. (2018). The role of self-regulated learning in students' success in flipped classrooms. *The Internet and Higher Education*, 41-53. doi:10.1016/j.iheduc.2017.09.003

Terada, Y. 2017. *How Metacognition Boosts Learning.* Available at https://www.edutopia.org/article/how-metacognition-boosts-learning, October, 2018.

Thompson, F. and H. L. Washington 2015. Critical thinking skills and teaching accounting: A comparative study. *Journal of Finance and Accountancy*. 19 1-8.

Turner, M. 2011. A method and resources to support accounting students to think critically. *Ako Aotearoa National Centre for Tertiary Teaching Excellence*.

 Zohar, Anat, and David, Adi Ben. 2009. Paving a clear path in a thick forest: a conceptual analysis of a metacognitive component. Metacognition Learning, 4, 177-195. doi:10.1007/s11409-009-9044-6

**ABOUT THE AUTHORS**

**Marianne M. Rexer** is the Robert S. Capin Professor of Accounting and the recipient of the highest faculty honor at Wilkes University – the Carpenter Outstanding Teaching Award. Dr. Rexer’s research interests are primarily in the fields of auditing and online earning although she has authored articles and books on auditing, financial accounting, managerial accounting, intermediate accounting, health care auditing, and online teaching.

**Anuradha C. Ghai** teaches Auditing, Fraud Examination, and the Wilkes University Sidhu School signature freshmen course in Entrepreneurship, Integrated Management Experience. Professor Ghai is an active member of the area chapter of the Association of Certified Fraud Examiners.