Identifying Mathematic Technology Tools for Student Success

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Abstract

Technology is immersed in everyday classrooms in hopes of creating effective, knowledgeable and successful 21st century learners. Today's students are expected to prepare for the modern workforce by developing essential skills in literacy, numeracy and using technology creatively and productively to solve problems by thinking deeply and logically. Teachers are expected to integrate technology into their daily lessons as schools strive to become leaders in using technology in the classroom.

With critical and thoughtful implementation, technology can help change and enrich the student learning environment. Improved transference skills, retention, application of knowledge, student engagement and motivation can result through immediate feedback and assessments using digital tools. While technology is a powerful tool, it requires schools to make financial investments and teachers to make time commitments. Therefore schools and educators must consider both potential benefits and challenges for student learning prior to its implementation.

Specific Google applications and their potential implementation in a direct instruction math classroom will be described. Each tool will include suggestions on how to use it in a purposeful way to achieve student success. Qualitative aspects will be used to select Google applications for each element of a direct instruction lesson for a junior high math classroom and suggested lessons evaluated on the SAMR (Substitution, Augmentation, Modification, Redefinition) model. The study will provide ideas using the tools to lead to positive and transformative impact on student learning, allowing teachers to see the value with technology in the classroom and realize technology lessons do not need to be elaborate and overwhelming.

Keywords: mathematics education, technology, Google Apps for Education (GAFE), SAMR model, direct instruction model

Table of Contents

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Introduction

Background

In a world where technology is so ubiquitous, it is no surprise that it has become so widespread in the K-12 educational classroom. Since 2000, Alberta Education has created a specific curriculum to emphasize technology as a “way of doing things”. The Information and Communication Technology (ICT) curricular outcomes are to be taught within core subjects and programs. Students are expected to understand, use and apply ICT in effective, efficient and ethical ways (Alberta Learning, 2016). Classroom teachers must not only infuse these outcomes into their subject curricular outcomes, but also feel the pressure to integrate new technology tools made available for the classroom at a growing rate due to the increase of funding schools are receiving from technology grants and the strive from each school to become leaders in technology integration (Pedro, 2012).

The adoption of technology in schools is often prescribed by policies created by administration to grant access to all students. Purchasing technological equipment provides stakeholders with a clear and high visibility of how schools are modernizing and providing quality education for their students (Pedro, 2012). With specific direction from administration, classroom teachers are often left with little choice but to integrate technology into their classroom, even if it is used marginally and with little purpose. Technology policies assume that technology can boost the quality of education students receive because they would learn more, better and differently with technology through additional access and opportunities. However, the quality of education is not determined by the technology tools integrated into the classroom, but rather by the quality of the teaching body to become efficient and transformative (Pedro, 2012). Due to the increasing investments into technology in the classroom, schools need to concretely measure and monitor not only its access, but also its use to determine if technology is making a difference in student learning and if the investments are worth the effort by all stakeholders.

There has been a shift in the student learning environment since the onset of technology in the classroom in Alberta Education, with fewer traditional lectures and more interaction with materials to increase student engagement and motivation in the classroom (Radosevich, Salomon, Radosevich, & Kahn, 2008). The positive impact of technology in the classroom includes higher student success compared to traditional methods of learning (Ashby, Sadera, & McNary, 2011; Bottge, Ma, Gassaway, Toland, Butler, & Cho, 2014; Pilli & Aksu, 2012), with a focus on the process of problem solving for better retention and application of knowledge to new content and context (Greene & Kirpalani, 2013). The connections between introduced concepts may be fluid and noticeable to a mathematics expert, but the interconnectedness of the topics may not be as obvious to the students. Technology can help students apply and transfer their knowledge by completing meaningful tasks and make connections between concepts learned. This transference of skill is not as easily obtained through traditional lessons introducing isolated topics.

Because today's students are so immersed with their digital tools, it is important that schools work with this digital connection leading to 21st century learners who possess essential skills in literacy, numeracy and be creative and productive users of technology while solving problems by thinking deeply and logically to prepare them for the modern workforce (Keane, Keane, & Blicblau, 2016). While there are benefits and a need for technology integration in the classroom for students, educators need to also be aware of challenges they face with technology.

The large investment and funding for technology in schools, if not implemented effectively, may not necessarily result in the same amount of learning gains by students (Pedro, 2012). Technology may in fact create a means for distraction in the classroom, providing an outlet for students to participate in off-task activities during classroom instruction (Awwad, Ayesh, & Awwad, 2013; Sana, Weston, & Cepeda, 2013) and in turn actually decrease their educational performance (Aagaard, 2015). Educators must consider the potential benefits and challenges of the technology tool and implement its use into the classroom if it provides a significant positive impact on student learning.

Technology is a powerful tool and can enhance learning, but it can not guarantee effective learning nor can it replace the active role of teachers making pedagogical choices to integrate the tool into the lesson in a meaningful and purposeful way (Mackinnon, 2002). Implementing technology into the classroom is not an easy task and can affect the learning environment as the teacher must take time away from the lesson. For teachers to deliver an effective lesson with technology, it involves extensive preparation that they may not always have the time, resources or support. They must review the technology tool or tools available, become familiar with it themselves and create well-intentioned activities that reinforce student comprehension and prior knowledge with related material (Campe, 2011). There is a deep learning curve for teachers to become familiar with the technology tool as well as maintain good user knowledge through constant program updates for them to make informed pedagogical choices to “what” technology should be used and “how” learning can be enhanced (Mackinnon, 2002). With so much available technology teachers are expected to use in the classroom, without support and time, the task to integrate technology can become unmanageable and daunting.

When attending professional development and teacher conventions, new and exciting software and technology are always introduced with their best features demonstrated in a short amount of time. It isn't until teachers try it on their own that they have additional questions and complications, but no one around to ask. As technology continues to become more advanced, additional software and tools become available for student learning. Digital tools that may not have been intended for educational use can become useful and effective in the classroom through teacher innovation. For example, the Apple iPad was not originally meant for classroom use, but now has become part of many students' everyday learning and is even on some school supply lists. The game Angry Birds was only a simple game at first, but with creative lesson planning, it is used in physics classrooms to calculate trajectory and speed. Businesses and companies looking for long-term contracts and a successful business transaction instead of enhancing learning and helping students often showcase only the highlights of the tool to teachers and schools and it is up to the teacher to discover the rest. Teachers need support to help them make informed decisions about the tool and if it supports their lesson goals and outcomes.

It is important for classroom teachers to be encouraged to continue to integrate different forms of technology into the classroom to enhance student learning and not be overwhelmed to the point of avoiding technology altogether. Some teachers may not feel as comfortable as others to integrate technology due to their lack of confidence and familiarity with the tools. To address these issues, additional support to assist teachers to review the vast number of tools available or inform them of other available tools can help increase their confidence and reduce their skepticism. The tool can only be as effective as what the teacher has planned for it in the integrated lessons to guide their students to meet their lesson objectives. For teachers to be able to teach students to make critical decisions about technology in their lives, they themselves must be able to do the same.

Purpose

The purpose of this project is to provide manageable ideas and suggestions for a junior high mathematic teachers who use a direct instruction focus to effectively and purposefully integrate technology into their classroom and achieve the intended student success. The goal is to begin examining Google Applications for Education (GAFE) available for many educators and districts through Google Suite to create a collection of suggested lessons using these available digital tools. My objective is to also demonstrate that technology can be used in a direct instruction classroom to help students effectively apply and transfer their knowledge and skills through meaningful tasks and make connections with their learning.

The direct instruction model used at the school I currently teach at is based on lesson planning models by educators including Madeline Hunter (see Figure 1). The model consists of six elements: introduction, teacher-led instruction, guided practice, independent practice, closure and homework and is the primary system of instruction evident in the classrooms. The school follows a traditional model where teachers "provide an orderly and structured environment, with properly sequenced teacher-directed instruction and strong home/school partnerships, where average children can excel in an academically oriented program" (Aurora Academic Charter School, 2017). Following the Alberta Education's program of studies, the school also includes an enhancement program for multiple subjects in each grade.

Figure 1. Direct Instruction Model for Aurora Academic Charter School

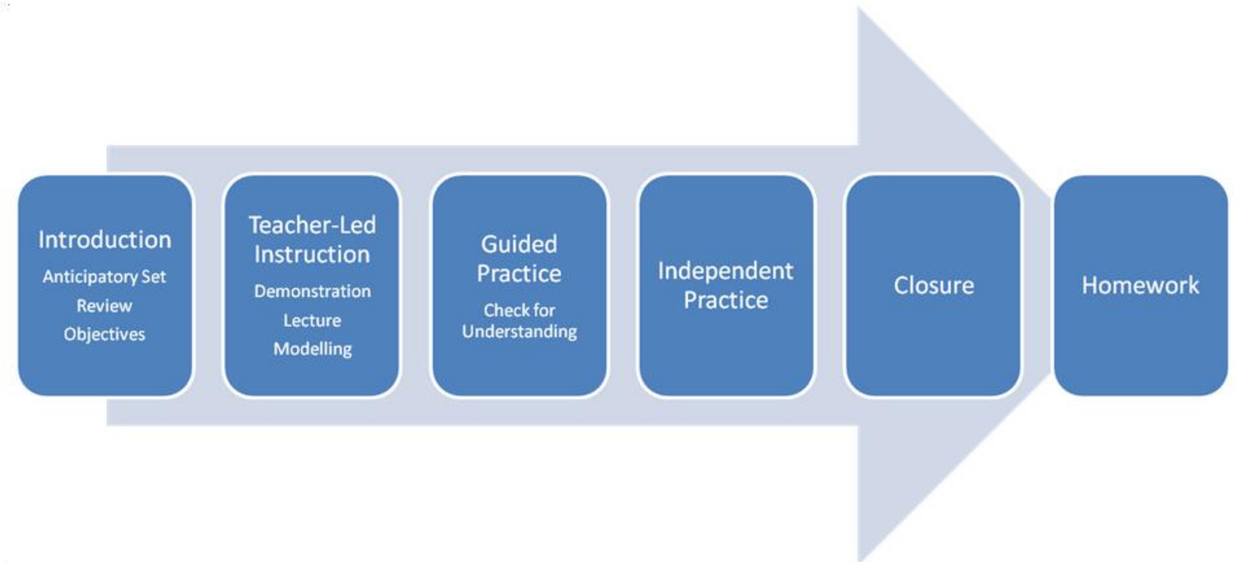

Figure 1. Based on models of direct instruction created by Siegfried Engelmann, Madeline Hunter, Barak Rosenshine and others, the Aurora Charter School Model of Direct Instruction is reflective of our school's vision of classroom instruction. This model, along with the Direct Instruction Strategies, formulates the system of instruction evident in every classroom.

The school currently has nine chrome book carts, two laptop carts and one iPad cart available for 18 classes in the middle school to share and will grow with an additional two classes in 2018-2019. With additional technology being purchased the following school year and the intention of reaching a 1:1 student to device ratio by 2019-2020, teachers need to be mindful of the way technology is used in the classroom. The readily available Google Applications for Education through the Google Suite package is a manageable starting point to learn how to use technology effectively and efficiently in the classroom for meaningful student learning.

Significance

The significance of the project is to illustrate that technology integration does not have to be a large overwhelming task and with support and a starting point of ideas and activities, teachers can create lessons integrating technology not only at an enhancement level, but also a transformative one. Using the collection of tools identified in a structured environment, teachers can see an example of how digital tools can be used effectively on a smaller scale. Therefore, teachers might feel more comfortable and confident in using new technology in the classroom and with the continued support from their school, develop effective lessons that integrate technology into their classrooms.

The expectation of technology use in the classroom is growing and it is important that teachers ensure their technology integration goes beyond surface learning and reaches student transformation. Technology often is only used in classrooms for reinforcement, finding information, turning in homework, and presentations, but needs to also be transforming the learning process (Mackinnon, 2002). With transformative technology integration in the classroom, students can learn essential 21st century skills to achieve higher success.

The implication of the project is to reduce the use of technology in the classroom for the sake of using technology, but instead to promote student learning (Campe, 2011). The pressure teachers may feel to integrate technology into their classroom may lead to misguided choices. Educators need to implement technology in a purposeful way to create a learning environment that fosters higher, deeper and meaningful constructive student learning that is worth the investment put forth by policy makers and stakeholders.

Literature Review

Technology Use in Schools

Technology is so pervasive in schools today that teachers can not only know the subject matter any longer, they must also know how the subject can be changed by technology applications (Niess, Ronau, Shafer, Driskell, Harper, Johnston, Browning, Ozgun-Koca, & Kersaint, 2009). Although teachers may feel the added pressure of integrating technology into regular lessons as a burden, core subject curricular outcomes are expected to integrate ICT outcomes to improve teaching and learning (Jude, Kajura, & Birevu, 2014). For technology integration to be successful, educators must revise their perspective on technology from what schools have to gain from technology to how technology can meet the needs of a new generation of learners (Jackson, Gaudet, McDaniel, & Brammer, 2009).

Math education and curriculum delivery has undergone many changes throughout the years in Alberta. From the traditional drill and practice with rote memorization, to the use of hands-on manipulatives, to discovery learning, educators must constantly be flexible and willing to change with the times by shifting roles and pedagogical methods by seeing the purpose of technology in the classroom (Crappel & Cremaschi, 2015). New digital tools can provide visuals and hands-on manipulatives that were not previously tangible for students to use and apply for better understanding. However, educators must also critically examine the tool and determine its purpose and rationale for implementation so not to fall victim to shiny new equipment that may be ineffective.

Because of many positive results in student performance with technology, school policies and funding highly support the increase of its integration (Pedro, 2012). It is up to educators to use their pedagogical training to effectively evaluate these tools before utilizing them to meet the goals of schools and support student learning.

Advantages of Technology in the Classroom

In a classroom where the teacher to student ratio varies from 1:20 to 1:40 or larger in some cases, it can be difficult for teachers to provide immediate feedback to individual students to guide their learning. Digital computer programs can be individualized to provide immediate feedback to students, leading to functional improvement as it allows for advanced questioning to stimulate students without the consuming time to get an answer (Campe, 2011). Hawkins, Collins, Hernan and Flowers (2017) suggest that the feedback loop is imperative and quick immediate feedback indicating the correctness of student responses with a positive indicator reinforces accurate responding. Immediate feedback can be helpful to students struggling with basic math fact fluency and help them improve through interactive drills through games and challenging programs. The immediate feedback can identify students' misconceptions quickly, allowing multiple attempts to determine the answer while critically reviewing the process (Pilli & Aksu, 2012).

A detailed analysis of the feedback provided by computer programs to teachers and students can act as a form of summative or formative assessment. The analysis can identify strong and weak areas for future improvement as a class or individual students (Radosevich, et al., 2008). Some programs provide strategies and extra practice for students in their weaker areas and notify the teacher when students with misconceptions are identified. Teachers can also reflect on the data provided to identify the need for alternative strategies for lesson delivery or the need for additional practice in their classes.

Boaler (2015) identified rote memorization of facts as an unnecessary repetition that may cause damage to students leading to anxiety and fear of math. Math facts are better learned through using the numbers in different ways and situations which computer programs can provide. Different representations of numbers create strong number sense which is foundational for higher-level mathematics. Kanive, Nelson, Burns, and Ysseldyke (2015) placed fourth and fifth grade students with math difficulties in one of three different conditions: computer-based practice, conceptual intervention and regular classroom environment. While they found that computer-based intervention had an increase in retention and increasing fact fluency, using manipulatives and virtual representations did not outperform the control group of traditional drill and practice as students may not have basic fluency to develop deeper understanding. Memorization of facts without number sense limits students' capabilities of interpreting and reasoning complex application problems. Using technology for classroom assessment can reduce the time teachers need to analyze the results as many can provide the results in different representations for the user, but more importantly, it can provide a different method of learning and practice for students to improve and master math fact fluency needed for students to develop deeper conceptual understanding.

Struggling with the process of problem solving, students are unable to transfer foundational skills due to an inadequate and limited conceptual understanding of problems (Jonassen, 2003). Sokolowski, Yeping, and Wilson (2015) found word problems became more accessible through the use of computerized environments by increasing students' interest in the content of the word problems. Through interactive tools, computer technology is able to make key relations for understanding more transparent and tangible, shifting the teaching practice from procedural to conceptual when building math competencies including problem solving, modeling and concept formation. Programs that can generate 3-D images can create compound shapes for students to understand overlap and exposed faces by allowing for manipulation of the actual shape visually to calculate surface area and volume.

Technology can help improve transference and bridge the gap between math concepts studied in the classroom with real-world applications (Greene & Kirpalani, 2013) by providing opportunities for task redesign and different problem representations influencing how they can be solved (Jonassen, 2003). Surface learning of concepts is often quickly forgotten by students if they carry little or no personal connection to them. Through meaningful and purposeful use of technology, it can strengthen conceptual understanding, long-term retention of concepts (Campe, 2011) and promote active understanding of meaning leading to better student outcomes (Pegrum, Bartle, & Longnecker, 2015). Visual and virtual tools that were previously unavailable without technology can provide the concrete manipulatives needed for a deeper understanding of certain concepts. The use of technology can increase retention, application of knowledge and reduce misconceptions (Radosevich, et al., 2008). The investigation into a blended instructional model on math performance by Bottge, et al. (2014) found an unexpected and unmeasured result of better retention of concepts. The multiple representations made possible through technology can create real-world applications for students to relate to and create a personal connection with, therefore creating meaning with the problem for better retention.

A goal of any teacher and classroom should be to provide students with opportunities to solve meaningful problems, motivate them to learn and build confidence to solve problems on their own (Bottge, et al., 2014). Students are always more willing to learn these skills when they are engaged and the best way to engage them is through technology which can provide diverse opportunities to draw on multiple related strands in common activities while integrating real-world applications by adding relevance to the concepts being learned (Milinkovic & Bogavac, 2011). Daily lessons in math needs to be interconnected and build upon each other, not introduced separately to create a better picture of the whole. Cross-curricular lessons are just as important to show the commonalities between subjects and grades. When students are shown the connectedness of all concepts learned, they can better understand the real-world applications of these concepts.

Romrell, Kidder, and Wood (2015) evaluated the impact of podcasts as a form of mobile learning and reported that using podcasts to review compared to reviewing with the textbook or course notes resulted in an increase of student engagement as students favored the idea of portable access of the material and the tool held their interest more. Technology is able to engage and hold the interest of students in the learning process longer because they have an effective interaction with their audience.

Increased student engagement with student motivation can affect math achievement and learning rates (Hawkins, et al., 2017). In the study of using student response systems by Radosevich, et al. (2008), student engagement and motivation increased because incorrect responses improved student attention on follow-up questions. Technology allows students a hands-on approach to take more responsibility in their own learning and demonstrate their learning as they understand they are held accountable for their performance. When students are given more control of their learning, it increases their motivation to learn (Smith & Suzuki, 2014).

Knight, Pennant, and Piggott (2015) found that interactive whiteboards have a positive impact on motivation as it offers students the ability to revisit the material and raises their self-esteem and confidence, knowing that they are free to experiment with the task. Bruce, McPherson, Sabeti and Flynn (2011) studied the use of interactive whiteboards in the classroom and the effect of hand gesturing that associated with the tool and noticed students' responses became more diverse and grounded. New problem solving strategies were also able to be developed by students as they became more cognitively receptive to future lessons. However, Pegrum, et al. (2015) cautions educators that new media may provide temporary motivation by generating new interest to disengaged students, but as the learning becomes more challenging and requires higher levels of conceptual understanding, students may no longer remain motivated and engaged. For technology to have a positive long-term effect on student performance, its integration must be carefully established with a pedagogical purpose in the classroom by teachers.

Challenges of Technology in the Classroom

There are some skills that technology can not replace in student learning. Laptop note-taking is less effective than longhand note-taking because of a student's limited ability to multi-task (Mueller & Oppenheimer, 2014; Kiewra, 1985). Note-taking affects learning through encoding and external storage as it improves a student's learning and retention. More notes taken with a laptop by verbatim transcribing lectures show less processing of information in students than efficient notes taken by hand that contain critical ideas expressed in minimal words (Mueller & Oppenheimer, 2014). Therefore, laptop note-taking can be detrimental to a student's performance since encoding and information processing is important to conceptual learning.

Immediate feedback may be an advantage for student learning, but in the subject of mathematics, where student work and the thought process is just as critically important as the answer, immediate feedback which only reviews the accuracy of the answer may not provide adequate and useful feedback about student learning and knowledge. Students' ability to learn and self-assess their progress through learning to check their work and determining if their answer is logical and reasonable is also an important skill that computers may not be able to teach (Campe, 2011). Effective computer programs that will support student learning should demonstrate an example of correct work for the student to model to help them identify their errors and improve their knowledge and math skill.

Using technology in the classroom often requires students to multi-task, placing large demands on cognitive resources while reducing a student's overall performance as it limits resources attending to processing, encoding and storing introduced concepts resulting in a reduced quality of information stored for later retrieval (Sana, et al., 2013). Laptop or other technology that is not necessary for student learning is discouraged as students are unable to split their attention between an academic primary task to a non-academic secondary one efficiently (Sana, et al., 2013). Awwad et al., (2013) suggest monitoring laptops during class time to reduce distractions including web surfing, games, movies and decreased focus. Meaningful laptop activities and tasks such as real-time classroom exercises related to the lesson can lead to effective and constructive learning in the classroom with technology, but teachers need to be mindful that student attention can easily be redirected by external stimuli (Aagaard, 2015). Technology challenges educational practice as it can lead to enhanced student performance when used effectively, but it can also lead to off-task activities and inefficient multi-tasking resulting in decrements in student performance.

As schools are expected to provide students with adequate learning opportunities to develop a better understanding and use of technology (Pedro, 2012), educators must be informed of all impacts and effects of technology while balancing its integration into the classroom through lessons and activities. The incorporation of all types of technology into everyday classroom lessons to achieve different results and higher level thinking for students to learn to apply ICT in effective, efficient and ethical ways as prescribed by Alberta Education (2016) can not be done by computers. It requires the lead of a teacher to use computers to help them diagnose and remediate student misconceptions and improve student understanding (Sokolowski, et al., 2015).

Program tools may be able to distinguish between right and wrong, but they have limited capabilities, being only able to judge the learner's input. Therefore students can only learn from the tool, not with the tool to construct knowledge (Jonassen, Carr, & Yueh, 1998). To achieve this level of learning, purposeful activities must be designed using the tool along with meaningful follow-up activities to check for student understanding (Campe, 2011). Computers are powerful machines and can benefit student learning, but it requires a teacher's pedagogical decision to decide the purpose of the tool and how it should affect student learning (Jonassen, et al., 1998). A teacher's attitude and expectation affects his or her confidence in implementing the technology effectively into the classroom (Knight, et al., 2005). To further student learning using new tools that were not previously available in the classroom, teachers must be encouraged to take the time to learn and consider how best to adapt these tools to the learning and content of math education (Sokolowski, et al., 2015).

Conceptual Framework

Constructivism

According to Piaget's Constructivist theory, learners must actively engage in their learning to make meaning with realistic activities (Mackinnon, 2002). Classroom lessons involving explorative math and reflective activities involve active learning resulting in higher engagement over passive learning where students receive and absorb information like a sponge (Strommen & Lincoln, 1992). Alberta Learning (2016) suggests effective resources for learning technology must include activities, projects and problems replicating real-life situations. Technology tools can be used to create authentic learning tasks for students to construct knowledge for deeper learning, letting them enter into an intellectual partnership to learn with the tool (Jonassen, et al., 1998).

Even though concrete experiences with a tool may lead to higher student performance, not all technology tools will help students achieve the same amount of success (Mackinnon, 2002). Many tools allow students to have a more active role in their learning, therefore increasing their own motivation and to some extent allow them to create their own knowledge (Pegrum, et al., 2015), but may not lead to deeper learning. Many models used to evaluate student learning have higher levels requiring students to construct their knowledge through individual creation of a task for learning to be at its best.

Categorizing Models for Technology

With an increasing push for more technology in the classroom, educators and related stakeholders need an effective method to measure the impact these tools have on student performance. When teachers make the pedagogical decision to integrate any particular technology tool into their lesson, they should consider if the tool can engage students in critical thinking and construct knowledge, not only judging their responses (Jonassen, et al., 1998).

While Bloom’s Taxonomy categorizes instructional objectives and assessment based on cognitive complexity on six different levels (Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation), SOLO Taxonomy (Structure of the Observed Learning Outcome) classifies learning into surface and deep learning (Keane, et al., 2016). Classroom tasks involving technology needs to be evaluated for its purpose and impact on student learning. SOLO Taxonomy allows online digital tools to be defined by quantitatively recalling facts or qualitatively relate and form judgments conceptually on tasks.

The ICT outcomes aim to teach students 21st century skills by broadening their skills from the fundamental 3Rs of Reading, Writing and Arithmetic to involve the 4Cs (Critical Thinking, Communication, Collaboration and Creativity) to better reflect and close the gap between education and technology (Keane, et al., 2016). Skills acquired through authentic classroom tasks involving technology can be evaluated by its impact on student learning by the different models, but the elements of each model are relational and not necessarily hierarchical. Therefore, elements may be met simultaneously through different tasks or lower skills may not need to be fully mastered before higher ones are met (Keane, et al., 2016).

The SAMR Model

Teachers need to invest time to review, learn and integrate new technology into lessons and may not have time to review all new apps as frequently as they are introduced or become familiar with their constant updates. The SAMR (Substitution, Augmentation, Modification and Redefinition) model created by Dr. Ruben Puentedura in 2006 (see Figure 2) helps identify the level of impact the technology may have on students and the teacher can use it to decide if it coincides with their goals and outcomes. While the two main levels of the SAMR model are similar to the SOLO Taxonomy (Enhancement and Surface Learning, Transformation and Deep Learning), the SAMR model has additional levels that allows for intermediate stages to be used to evaluate digital technology tools and for educators to use as a stepping stone to redesign tasks to utilize the tool more transformatively if they wish for a different impact on student learning.

Figure 2. The SAMR Model

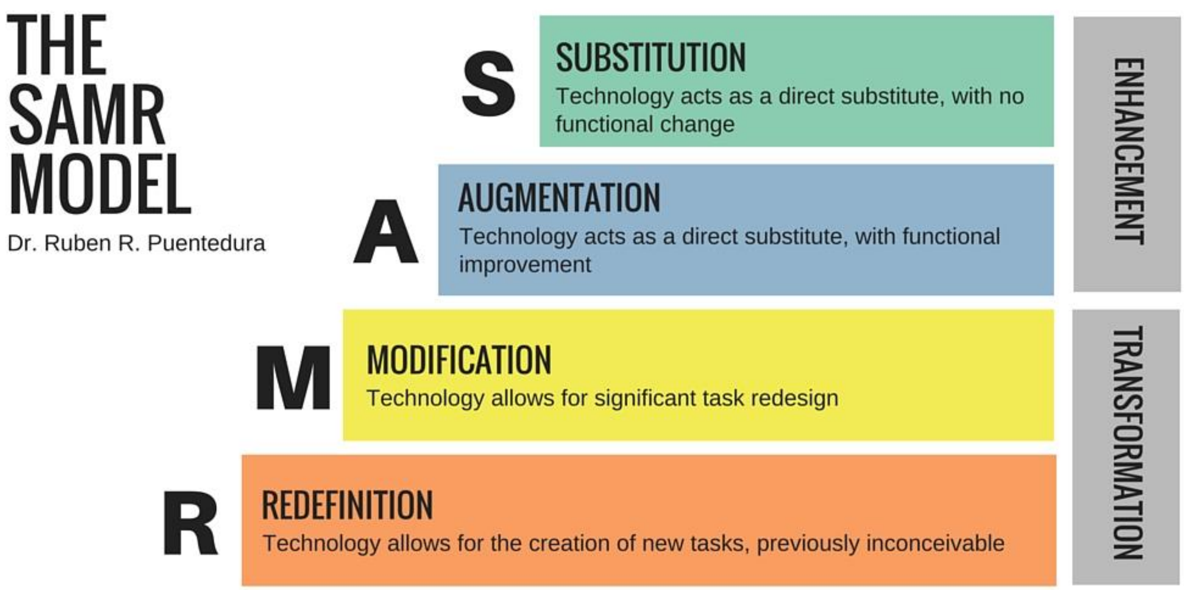

Figure 2. Created by Dr. Ruben Puentedura to identify technology implementation in classrooms. https://commons.wikimedia.org/wiki/File:The_SAMR_Model.jpg

The four-level SAMR model can be used to select, use and evaluate technology in the classroom, but teachers are encouraged to aim for the transformative levels (Hamilton, Rosenburg, & Akcaoglu, 2016). The two enhancement levels can help enhance a lesson through substitution, but with no functional change or augmentation with some functional improvement. The two transformative levels lead to transformative changes in student learning as the lesson may undergo modification through a redesign of a task with the technology or redefinition where technology has allowed for the creation of new tasks that was previously not possible without the tool.

The SAMR model follows a rigid hierarchical framework encouraging educators to use technology in a transformative way rather than an enhancement one to be more effective (Hamilton, et al., 2016). It does not favor the enhancement levels and discourages it when in fact all levels can improve student learning. De Witte, Haelermans, and Rogge (2015) found that while computer assisted instructional tools worked at the lowest enhancement level, they can be a good substitution method to reinforce learned material and help a student catch up through drill and practice while assisting the teacher to differentiate among students.

While the SAMR model does not address the context of individual schools and the lack of resources that may hinder its ability to transform student learning, it places heavy focus on changing a technology product rather than the learning process (Hamilton, et al., 2016). The technology tool's objective should be to enhance and support student learning and the role of the teacher is to plan for instruction that offers students meaningful learning opportunities with technology.

When using the SAMR model to evaluate technology, an educator may use the model to guide his or her pedagogical decision, but needs to the main purpose of promoting student learning clear. Tools may appear at the surface to only be an enhancement to students, but with well-intentioned activities and lessons by the teacher, the tool can be raised to a transformative one to have a deeper impact on student learning. It is not the tool itself that leads to redefinition, but how the teacher uses the tool for redefinition that makes the difference (Strommen & Lincoln 1992).

Romrell, et al. (2015) found that lessons involving technology were so complex that they tend to reach beyond the enhancement level of student learning. The positive benefits of meeting the transformative levels outweighed any obstacles and extra work needed by the teacher.

Having appropriate technological support, clear pedagogical integration of the tool clearly stated to students and detailed plans to manage the technology may help reduce the complexity and obstacles of using technology in the classroom (Romrell, et al., 2015). With a detail plan and purpose, educators can use the SAMR model to evaluate the vast technology tools used in classrooms to prepare students for the digital age, meeting the goals of the ICT curriculum to be lifelong learners and think in ways that was never thought possible (Alberta Learning, 2016).

Methods

In order to create a collection of suggested lessons using GAFE (Google Apps for Education) as a digital technology resource for teachers of junior high mathematics, I plan to use Dr. Ruben Puentedura's SAMR (Substitution, Augmentation, Modification and Redefinition) model for digital technology integration to qualitatively review and identify potential GAFE and accompany them with suggested lessons for each of the direct instruction element. Since technology integration has different impacts on students based on related activities (Keane, et al., 2016), the project will include categorizing the tools with the SAMR model.

GAFE that will enhance student learning and potentially lead to a transformative change in the junior high math classroom will be identified. Creating suggested lessons based on various components of the technology tool will demonstrate how each tool can be effective in student learning and how a teacher can successfully achieve surface or deep learning with them. It will address how teachers can use different applications in their math classrooms to achieve their ICT goals and outcomes and how each tool can assist student learning at each level of the SAMR model.

The suggested lessons based on the Google tool's qualitative features will include some strengths and limitations for the digital tool as well as links to other resources providing help and assistance such as existing video tutorials. Through blogs, websites such as Learn Alberta, continued conversations with teachers and educators, professional development and conferences, Google tools will be identified and added to an already existing list of tools currently used in my classroom. One preferred Google tool will be selected and suggested for each of the direct instruction element: introduction, teacher-led instruction, guided practice, independent practice, closure and homework for the model used at the school I teach. Classroom activities with the tool for student learning will be described on the SAMR model. If the tool mostly suggests a lower enhancement level, suggestions on its application may be made to increase it to a transformative level on the SAMR model.

Due to some potential overlapping functions of the tools that can be used with more than one element of the direct instruction model, a selection process based on the more frequent and popular applications used by teachers through conversations will decide the tools that will be included in the bank of resources for each element.

Some limitations of this project involve the dynamic nature of technology where existing tools undergo constant changes with upgrades and the ceaseless number of new tools made available each year, making previous tools or activities irrelevant. However, the bank of resources will provide teachers with a place to start to obtain information on ready-to-use tools and ideas for activities involving technology in the classroom. Teachers will be welcomed to modify activities with newer tools as they are made available and updated with additional features to fit their classroom environment and students better.

The completed project, a Google Slide presentation digitally available through the link provided in Appendix A, will consist of lesson suggestions designed specifically for each element of a direct instruction math classroom, and can easily be shared with other educators for further collaboration.

Since there is no data collected from human participants, an ethics application was not done. Information gathered for the project will be from literature review and personal experiences. An effort will be made to identify and review tools with an unbiased analysis and to consider copyright laws when identifying specific names of online resources.

The Resource

With the growing number of technology tools made available to educators every day, the few mentioned in this project is only a small sample. Even within the Google Suite itself, there are additional communication and productivity tools available to foster student, parent and school relationships. Gmail, Hangouts and Blogger can be effective tools to communicate with parents as student's success at the school relies on a strong home/school partnership. Drawings, Keep, Calendars, Sheets, Google Earth, Tour Builder along with various extensions and add-ons available can assist educators with productivity in their classrooms and help create more engaging lessons.

It is important to also recognize that each Google tool identified in each element of the direct instruction model is most effective when used together as a suite and many can cross over to various other elements. For example, Google Classroom and Google Sites can be used for all elements of the lesson, Google Slides can be used in teacher-led instruction, guided practice or homework, and YouTube can be an effective closure to a lesson as well. Using these Google tools together can potentially improve student's transference skills by providing them with a platform to build connections between concepts and ideas previously learned through different representations (Jonassen, 2003). The possibilities can be endless, but the small sample of tools described here with suggested transformative lessons is not meant to overwhelm educators, but rather show them the possibility of gradually transforming student learning with technology.

One important feature in the Google Suite tools is the ability for teachers to comment and provide immediate feedback to students. This open line of communication allows educators to identify students' misconceptions quickly and provide useful and meaningful feedback to students encouraging them to critically review their learning (Pilli & Aksu, 2012) while remaining engaged. Feedback in this form not only has the ability to review the accuracy of the answer, but also the student's thought process through the personal exchange of questions and answers between the student and the teacher or other students. Students' communication skills, ability to self-assess their progress as well as explain their learning to others is an important skill that computer programs can not teach (Campe, 2011), but these Google tools can help create a platform for these meaningful exchanges to occur.

Identifying lessons in a direct instruction model provide teachers with a structured framework to begin analyzing the potential possibilities of each Google tool in the classroom. The progression in the lesson using technology through each of the six elements allows for educators to observe how transformative learning can be achieved, taking teacher-created tasks to become student-centered tasks (Roberts, 2013). However, it is also important that educators understand not all lessons need to include technology and not all transformative learning looks the same. Some lessons may be more effective with pen and paper or hands-on manipulatives and a task defined as redefinition can be subjective. A task may begin at the substitution level, but teachers should not view it as the beginning of a steep climb. The task design may have initiated with the teacher, but when students are given the correct tools and support, their innovation may surprise you and turn the task into a redefined task previously inconceivable (Roberts, 2013).

The advancements and recent shift on the importance of technology in the classroom should not overshadow the importance of the teacher's pedagogical decision to decide what and how to use the technology tools to impact student learning (Jonassen, et al., 1998). It is still important to recognize that the technology is not the most important object in the classroom for student learning, but rather the quality of the teaching body to use that tool in a transformative and efficient way (Pedro, 2013). Although learning and becoming familiar with a multitude of technology tools will take time, creating well-intentioned activities to reinforce student learning can increase student motivation and engagement affecting their achievement and learning rates (Hawkins, et al., 2017). The potential benefits toward student learning are worth the time spent training and evaluating these tools for the classroom.

This collection of tools and lessons using GAFE in a junior high mathematics classroom is only the beginning of many tools to integrate into the classroom to improve student learning, productivity and communication to build better relationships. There is a potential for additional tools to be included and shared in the future. The current suggestions will be shared with teachers at AACS to encourage them to continue to learn and explore different ways of using GAFE and other available technology tools in their classrooms to transform student learning while fostering effective, knowledgeable and successful 21st century learners.

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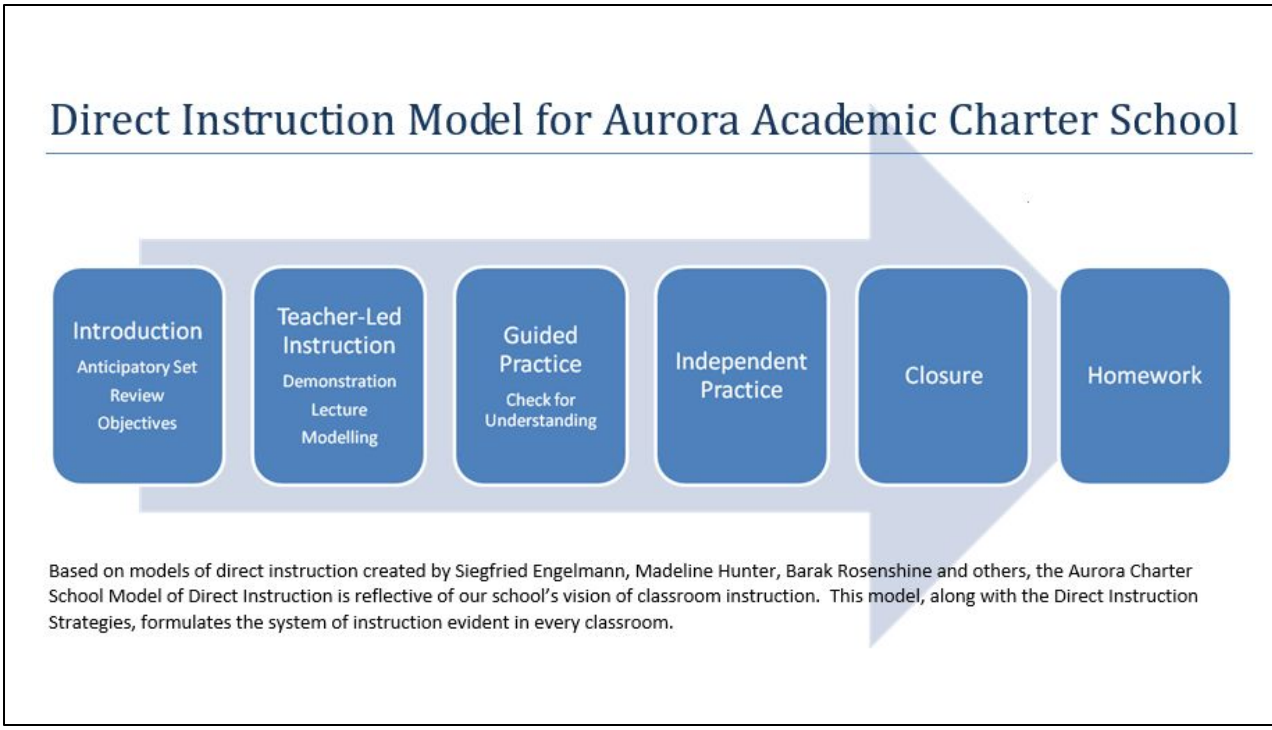
Appendix A

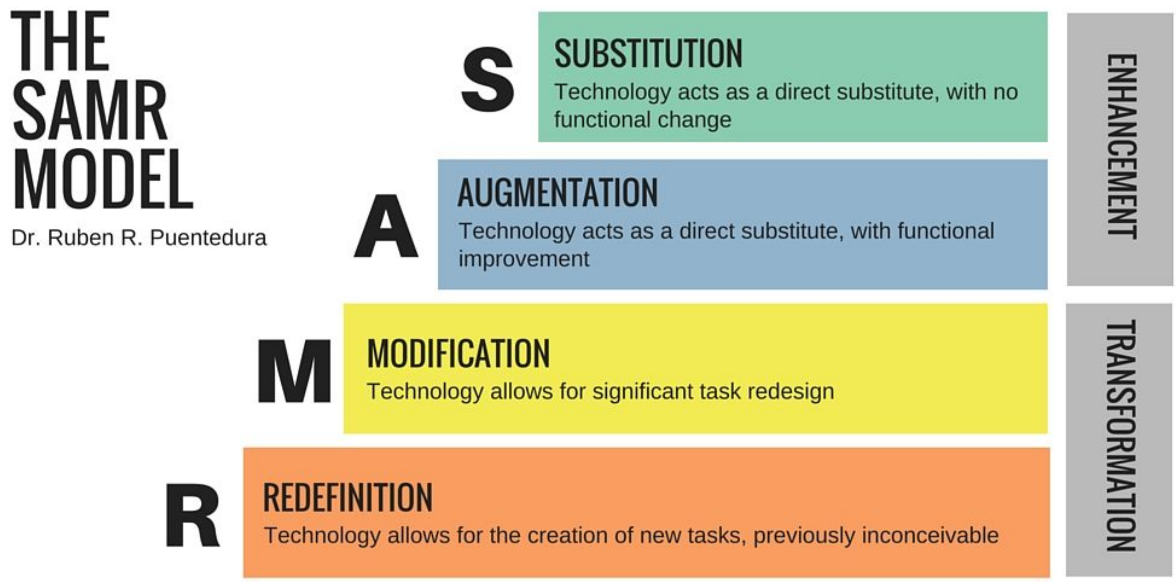
Google Slides Project Link: https://goo.gl/wChk7s

(See attached document)

Project idea came from my personal interest with technology and the amount of technology our school (Aurora Academic Charter School) has purchased and will continue to purchase. I found there were many available applications and programs available for teachers and everyone was using different ones. I wanted to master a few and use them effectively in my math classroom. Recently, I completed my Google Certified Educator Level 2 and found that the Google Suite has many amazing tools that can be easily incorporated into the classroom, reaching different levels of student learning.



Review of Direct Instruction Model created for Aurora Academic Charter School. A regular math class routine for me include introduction of a new topic and objectives. Through questioning and student inquiry led by the teacher, students will meet the objective of the lesson, then practice with examples as a whole class. Additional problems are assigned with various difficulty levels and followed by a check for understanding, usually in the form of a mini-test. Students are required to complete corrections from mini-tests for homework and review.



https://commons.wikimedia.org/wiki/File:The_SAMR_Model.jpg

The SAMR model was chosen to organize different activities possible with Google apps for education (GAFE) because of its simplicity and many Aurora Academic Charter School teachers attended the Charter School Conference when it was introduced as part of a keynote presentation. Many other models were considered and have similar levels of learning.

Introduction

Youtube: Video sharing website where users have the ability to save videos into a playlist and subscribe to channels

S	Search for videos related to the stated objectives to serve as an introduction to the lesson or topic. Although playlists can be shared with others through email, link and blogger, the video used only replaces an instructor giving the same information.
A	Search for videos related to lesson to serve as an introduction to the objectives or a review of prior knowledge, but video allows teacher to showcase an idea that may not be easily brought into the classroom.
M	Insert "cards" into the video with guiding questions to allow for student inquiry in the topic and review previous related concepts.
R	Allow students to locate and put together a playlist of videos to introduce and teach a particular lesson, review related concepts or be self-directed learners.

YouTube is a popular website that houses many resources for the classroom and can be used to introduce topics visually. Many people only use it for entertainment and videos, substituting other forms of topic introductions, not knowing that there are many different things available within the website itself to make it more accessible and useful for teachers, including sharing already created playlists with collaborating teachers or departments and creating "cards" that can pause the video and allow teachers to insert questions to be answered to reach a transformative level of learning. Using the tool differently in the classroom can reach different levels of learning, depending on the purpose of the tool for the lesson selected by the teacher.

Google Sites

Teacher-Led Instruction

Google Sites: Simple tool to create an interactive website that easily allows for users to navigate instructional content and information

S	Lessons including docs, calendars, maps, images, forms and charts and other related learning materials (Eg. videos from Youtube and Khan Academy) can be linked for easy student access all in one location for classroom demonstrations, lectures or modelling.
A	Students commenting can be enabled for open discussion and questions to be posed in real time throughout the lesson. Discussion topics can be created in real time encouraging student participation in the demonstration and lecture.
M	Allows for student differentiation by setting up assignments or discussion with additional demonstrations, lectures or models for students to work on at their own pace.
R	Allows for the possibility of a flipped classroom (instructional strategy where students are introduced to classroom content including demonstrations, lectures and models at home and practice is completed at school).

Google Sites is another platform to create a website. With some organization, learning materials and resources can be made digital and available for students at all times, allowing them to learn at their own pace at a modification or redefinition level of student learning. Students can have open discussions with each other and provide help to classmates struggling. The website is not only a resource page, but can be used to create a redefined community of learning among students. The teacher remains in control and can add his or her own comments to guide students properly.

Guided Practice

Google Docs: Web-based application to create and edit text documents to share with others

S	Pre-made classroom reference materials can be shared with students as a packaged digital lesson. The format of notes and examples provided digitally only replaces an instructor giving the same information. EqatIO extension creates math expressions quickly and easily.
A	Students can add direct comments to users (Eg. the teacher) to ask questions and comments and the teacher can reply with links and an open discussion to check for understanding.
M	Gives students an opportunity to add digital media to their own notes to personalize and demonstrate their learning in a multi-dimensional way through images, links and videos.
R	Opportunity for collaboration between the teacher and the student and student with other students by allowing the student to share his or her learning with others and use the collected information to create alternative reviews best suited to their learning style. The end product can be used by teachers to monitor progress and check for student understanding.

Google Docs may be similar to Microsoft Word, but it has many advanced functions. The similar notepad format allows students and teachers to use a familiar format to share notes and textual information. By allowing multiple editors and live updates to the documents, teachers and students can receive immediate feedback with the tool through comments and attachments, augmenting their learning. Immediate or quick feedback can be helpful to students as formative assessments. Teachers can slowly become more familiar with Google Docs by using it as a substitution tool first for notes and examples and incorporate additional features in future lessons before using the tool transformatively in a redefined lesson with teacher and student collaboration. This tool can be an effective enhancement or transformative tool for the teacher, depending on the goal of the guided practice defined by the teacher for the particular lesson.

Independent Practice

Google Slides: Web-based application to create and edit presentations to share with others

S	Individual meaningful practice can be assigned and completed to reinforce learning in Slides. Completing work digitally only replaces the textbook and worksheets provided in classrooms.
A	Students can add direct comments to users (Eg. the teacher) to ask questions and comments and the teacher can reply with links and begin open discussions with particular difficult problems or clarify concepts.
M	Teachers can create and embed a help videos to guide students outside of the classroom and reinforce learning when independent practice is completed at home.
R	A classroom shared document can be used to open discussion among all students allowing them to help each other with practice problems. Students can post questions and others can provide help through inserting images and videos.

Google Slides is more than a presentation software. The one page visual allows for students to focus on one question at a time, substituting textbook examples. This tool is actually quite useful for every aspect of the lesson and can be used for the entire lesson if a teacher wishes. Although Google Docs and Google Slides share many of the same advanced features and can effectively be interchanged throughout the lesson, the visual layout of slides suggest one slide per idea/question, forcing the user to be more succinct. From experience, Google Slides is more effective for independent practice. Students can start individual questions and comments on each slide for every question and receive feedback from the teacher and peers, redefining their learning in a transformative way.

Closure

Google Classroom: Web service that allows teachers to create, distribute and grade assignments easily

S	Organized set of resources and lessons for students to access any time to summarize the lesson and objectives including individual student docs, calendars, maps, images, forms and charts and other related learning materials (Eg. videos from Youtube and Khan Academy) can be linked using "Share to Classroom" extension for easy student access all in one location.
A	Students commenting can be enabled for open discussion or private messages and questions can be posed in real time throughout the lesson. Questions, Assignments with linked documents and Announcements can be added throughout the lesson to reinstate the objectives.
M	Creating on the spot short questions based on the completed lesson as "Exit Slips' can be used to summarize student learning and reinstate objectives.
R	Allows for differentiation by setting up assignments or discussion for particular identified students to work on at their own pace. Assignments can be scheduled to post at a later date.

Google Classroom is another tool that can be used for all aspects of any lesson, but because of its similar set up as a website that can branch out to all other applications, it is an effective closure tool to summarize the lesson into one place. With upcoming updates, Google Forms (surveys) can soon be created directly from Classroom and can used to make on the spot "exit slips' to reach a modification level of learning. Questions can be shared immediately and answers viewed at-a-glance, allowing the teacher to identify misunderstandings quickly. For teachers new to the Classroom tool, starting off using it to only enhance their lesson may be sufficient and then slowly incorporate additional features throughout the year to redefine their teaching. Reaching a transformative stage with Google Classroom for teachers unfamiliar with the tool may be too overwhelming in the beginning.

Homework

Google Forms: Questionnaire tool to collect and analyze data or create a quiz

S	Individual practice can be assigned and completed in Forms. Completing work digitally only replaces the textbook and worksheets provided in classrooms
A	Create a Google Form Quiz that autogrades and sends summative feedback. Flubaroo extension allows for short answers to be included in the question answers.
M	Students can create their own Form or Quiz by embedding various digital media to review objectives stated in class and share their creations with others.
R	Students can create a quiz in the format of a "Choose Your Own Adventure" form where incorrect answers are redirected to additional videos, questions and help content before returning to the quiz. With the redirection, students will have to understand what common misconceptions may occur and how to correct them.

Google Forms is more than a survey and recently has added a quiz feature for teachers to easily utilize it as a test. With available add-ons, marking can be automated and immediate feedback be provided to students to quickly identify misconceptions. While these enhancements may not transform student learning, it provides teachers with summative and formative assessments. Once the concepts have been mastered, students can transform their learning through task creation of their own to showcase their knowledge.