Ranthony A. C. Edmonds

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Final Project with Revision

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Introduction

This proposed instruction is intended to address the foundational issue of understanding the relationship between elementary word problems and algebra. The beauty of mathematics is that it can be used to solve many real world problems. While the more interesting problems require advanced mathematics, many questions arise in our everyday lives can be solved using basic algebra skills.

To solve problems using algebra, they must first be translated into algebraic equations that can be solved. The first time this skill is taught is typically in a pre-algebra or algebra 1 course after students have learned how to solve basic algebraic equations for a given variable. The motivation for this instruction was to ensure that students receive a solid introduction to this topic. Solving word problems is something that will be required over and over and over again throughout schooling, sometimes even in courses that are not strictly mathematical.

What follows in this paper is the analysis process leading to the design of the instruction. Afterwards is a discussion on how student learning will be evaluated with regards to the aforementioned design. Lastly, a reflection by the author of the personal effects of undergoing the instructional design process is included, followed by references and appendix including samples of instructional materials.

1 The Analysis Process

Based on my experience tutoring and teaching throughout the years I have noticed that word problems are notoriously difficult for students at all levels, and in particular when they are first introduced to algebra, many students have difficulty translating algebraic expressions into word phrases or equations. This requires a different set of skills than solving a traditional algebraic problem that I think is important to address as these types of problems represent the type of math that shows up in our day to day lives.

After determining this instructional need I identified the most appropriate learners as pre-algebra students or algebra 1 or higher students in need of remediation with regards to this topic. I based the context analysis of my instruction on the three types of contexts highlighted in Morrison, Ross, & Kemp: orienting context, instructional context, and transfer context (Morrison, Ross, Kalman, Kemp 2011). To determine the content analysis instead of using Morrison, Ross, & Kemps approach to developing instructional objectives I followed Dick, Carey, and Carey's model and created the flow chart and create the subordinate goal steps given in the sections below. In order to determine the learning category associated with each learning outcome I used Gagne's Theory of Instruction (Driscoll Ch.10).

When determining the motivational gaps present for my instruction I used Keller's ARCS model to determine that attention and confidence would be the issues most pertinent to this instruction. Based on the article *Development and Use of the ARCS Model of Instructional Design* by John Keller I decided that Concreteness and Participation would be the best strategies to use to combat attention issues and that is why I suggested the use of visual aids like marbles and group work so that students work

together to stay engaged (Keller, 1987, p.4). Similarly, based on this same article I concluded Self-Confidence is the best strategy to use to deal with issues of confidence (Keller, 1987, p.5). That is why there will be a build up of difficulty as the lesson goes on with many concept checks along the way so that students do not feel overwhelmed and give up.

1.1 Needs Analysis

Students have difficulty transforming word phrases and problems into algebraic expressions and equations. For example, suppose Kenny is two years older than Sandy. Given that Sandy is 18, most students have no problem saying that Kenny must be 20 years old. However, faced with the task of making this an algebraic expression, many struggle with defining x to be Sandy's age and then defining Kevin's age to be $x+2$. This is a very important problem to address as it gives students a way to begin to use algebra to solve real world problems.

When students learn algebra they often spend a lot of time solving equations. However, outside of an academic setting, they will not be handed equations to solve but instead will encounter questions that can be answered if they are able to turn the situation into an equation. For example, how much should I save from every paycheck to pay for my college application fees? How many pizzas should I order to make sure everyone at the party has at least two slices?

Additionally, this skill will be assumed as students continue in math courses. For example, in geometry two angles are said to be complementary if they sum to 90 degrees.

Students are usually fine to say that if an angle is 60 degrees its complement is 30 degrees, but falter when asked to find the measure of an angle that is two times to the measure of its complement. Without the skill described above students will struggle in courses that rely heavily on the ability to come up with equations rather than just solving those that are given.

1.2 Learner Analysis

The learners are middle school aged students, 11-14 years old, in the equivalent of a pre-algebra course. The learners could also be middle school or high school students in the equivalent of an algebra 1 course that are in need of remediation with regards to this skill. Students should know what a variable is in an algebraic sense and how to solve basic multistep equations for a given variable. They should also know how to substitute values of specific variables into a given expression and then simplify.

As the students are young adolescents they are not to be treated as 'mature' learners. At this age it is not expected that they will be able to sit through long periods of lecture styled instruction without getting restless. Also, at this stage in their schooling they could have mixed views towards mathematics, with a majority feeling that it is a difficult subject that they are not very good at. It is assumed that the students are responsive to visual, kinesthetic, and social learning styles as the lesson will involve all three.

1.3 Context Analysis

Orienting—Most middle school students have the immediate goal of getting a good grade in a class and aren't necessarily focused on building a comprehensive set of math skills to help them in the future. They also believe that math is a difficult subject and often have negative attitudes because they believe the subject matter will be too hard for them to grasp. These negative attitudes also stem from the belief that the material learned in class won't have much to do with their 'real lives.'

Instructional—It is assumed that the instructor will have access to visual learning aids, like an overhead projector, a whiteboard, or a chalkboard. In addition students should be in a setting where both individual and group work can be done. Lessons are based on 45-50 minutes of instruction time.

Transfer—Word problems and phrases will come up again and again in various math courses and even science based courses. Translating word phrases and expressions is a skill that is required in algebra 1 and is relied heavily on when applying some concepts in geometry. The ability to understand and interpret word problems involving basic multi-step equations will also be considered an entry behavior in high level math classes where solving word problems becomes more complex.

1.4 Content Analysis

<u>Goal Statement:</u>

Students will be able to analyze phrases and word problems and determine the operation(s) and the order of those operations. They should then be able to represent phrases and word problems as algebraic expressions and equations. In the cases where they set up an equation, they should then be able to solve the equation describing what the answer represents in terms of the original problem.

The above goal statement can be broken down into the following smaller goal statements/learning outcomes:

(1) Students will be able to read a word phrase or problem and determine the operations indicated and the order of these operations

Learning Category: Intellectual Skills—Learning Concepts and Problem Solving

Explanation: Students will learn the key words that indicate subtraction, addition, division, and multiplication. They will then be able to identify these terms when they appear in a problem and determine the order of the operations indicated.

(2) Students will translate word phrases and problems into algebraic expressions and equations

Learning Category: Intellectual Skills—Learning Concepts and Problem Solving

Explanation: This requires mastering the concept of combining operations into an algebraic expression or equation. As no two problems are example alike they will have to determine the appropriate way to set up an expression or equation in each given situation.

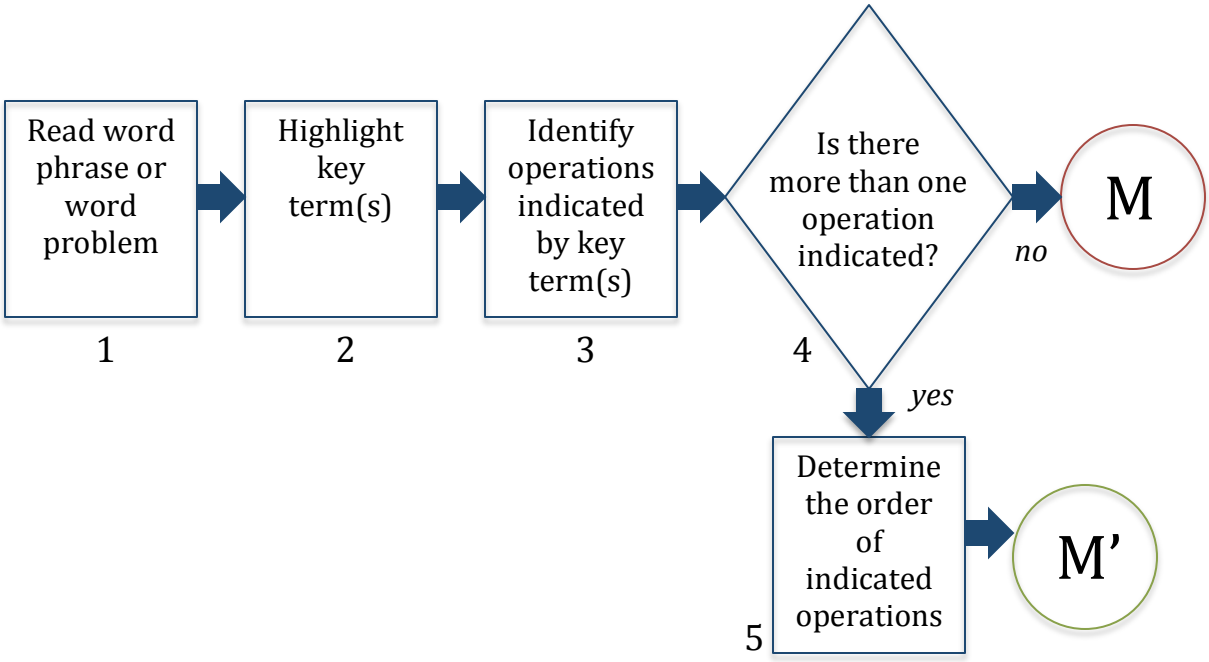
(3) If a student sets up an algebraic equation, they will solve for a given variable and interpret the results

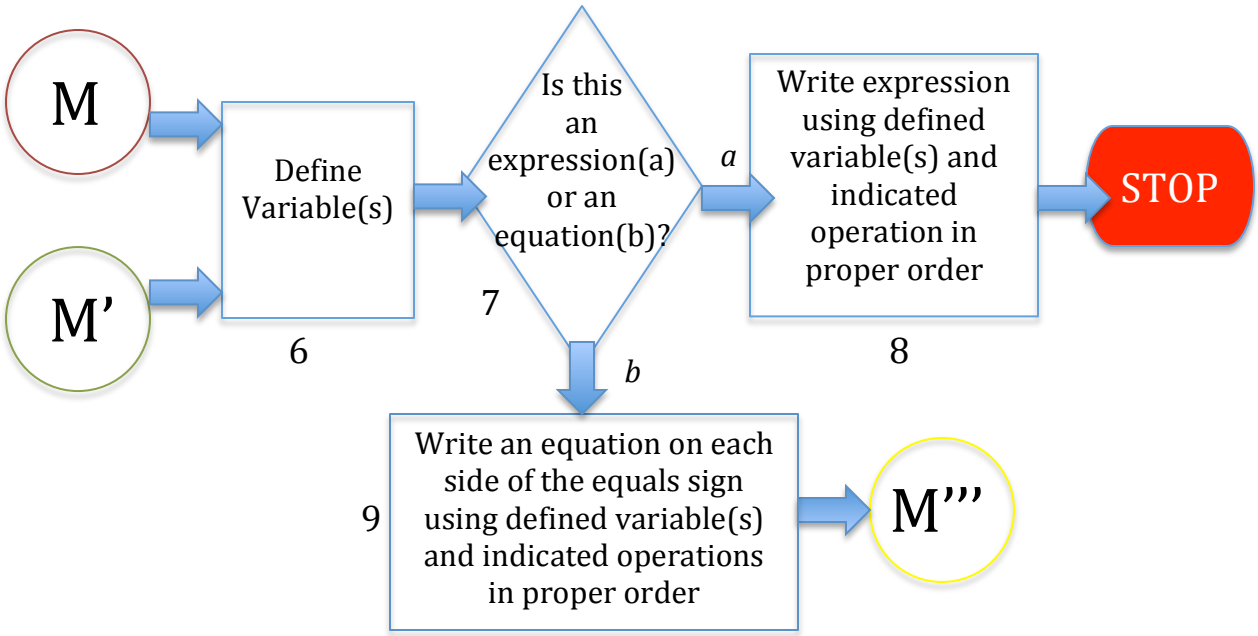
Learning Category: Intellectual Skills-Problem Solving

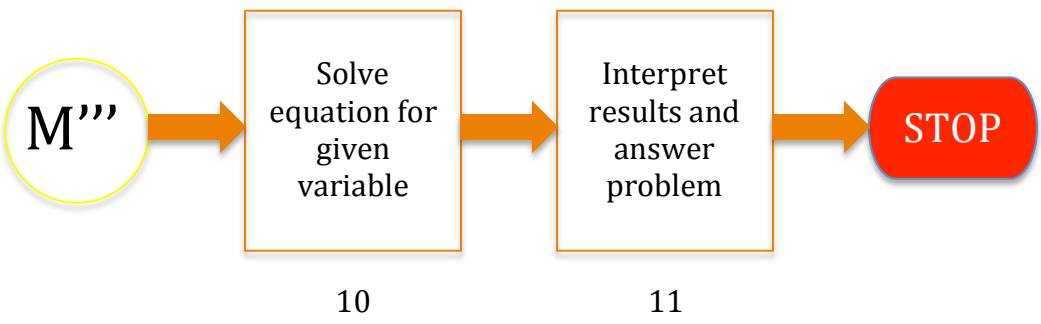
Explanation: They will be solving an algebraic equation and then explaining what the answer means in terms of the variables that were defined in the set up.

Goal Steps:

Please see flow chart attached on the next page. The solid black lines separate the chart into steps based on the three learning outcomes above. Each goal step is clearly numbered.


Read word phrase or word problem
Highlight key term(s)
Identify operations indicated by key term(s)
Is there more than one operation indicated?
no
M
yes
Determine the order of indicated operations
M'
1
2
3
4
5


M
M'
Define Variable(s)
Is this an expression(a) or an equation(b)?
a
Write expression using defined variable(s) and indicated operation in proper order
STOP
b
Write an equation on each side of the equals sign using defined variable(s) and indicated operations in proper order
M'''
6
7
8
9


M'''
Solve equation for given variable
Interpret results and answer problem
STOP
10
11

Subordinate Skills:

Learning Outcome (1)

- Step 1) None
- Step 2) Students will be able to Identify terms that indicate an operation (addition, subtraction, multiplication, and division)
- Step 3) Once a term that indicates an operation has been identified, students will then correctly determine whether that term indicates addition, subtraction, multiplication, or division
- Step 4) Students will decide if there is more than one operation present in the problem
- Step 5) Students will determine the order of the operations present in the problem (ex. Should they subtract before or after they multiply?)

Learning Outcome (2)

- Step 6) Students will learn to define variables when given a word phrase/problem
- Step 7) Students will understand the difference between an expression and an equation
- Step 8) Students will learn to write an expression based on defined variables with operation(s) in the correct order
- Step 9) Students will break an equation into an equals sign with two expressions on either side and use the skill from Step 8

Learning Outcome (3)

- Step 10) Students will solve a basic algebraic equation
- Step 11) Students will interpret the solution of an algebraic equation with defined variables and use this solution to answer a problem

Entry Behaviors:

In **Step 6** it will be assumed as an entry behavior that students understand what a variable is and have seen them predefined. This lesson focuses on ensuring that given a word problem, they can define appropriate variable(s) themselves. In **Step 7** it is assumed that students are coming into the lesson understanding the difference between an expression and equation. In **Step 10** it is also assumed that students understand how to solve basic algebraic equations. Assuming this is important because without this previous knowledge the lesson will be too confusing. When students are introduced to solving algebraic equations they are first introduced to expressions.

The whole purpose of this lesson is to show students how to set up their own algebraic expressions and equations properly, and then to interpret the results. To do this we have to assume that they can successfully manipulate expressions and equations that have been set up for them and gave basic algebraic competency expected of someone in a 'pre-algebra' focused course.

Learning Objectives:

Objective 1a/1b—Students will be able to read a word phrase or problem and determine the operations indicated (1a) and the order of these operations (1b).

Conditions of Performance—With a partner, students will read a word phrase they must be able to identify the words in that phrase that indicate subtraction, addition, multiplication, and/or division. Afterwards, given the same word phrase they should be able to indicate the order of operations. For example in the word phrase: two less than three times a number the operations are multiplication and subtraction and the order is multiplication and then subtraction.

Criterion—Students will be given an in-class worksheet and homework assignment that will ask them to match key words to the operation that they indicate. They will also have to write a basic algebraic expression given a word phrase that involves these operations and by doing so they will have to put the indicated operations into the appropriate order.

Objective 2a/2b—Students will translate word phrases into algebraic expressions (3a) and word problems into algebraic equations (3b)

Conditions of Performance—Given a word phrase or problem students must define variables and then use them to write an algebraic expression or equation.

Criterion—Students will be given an in-class worksheet and homework assignment where they will be given a word phrase or problem and asked to translate it into an algebraic expression or equation

Objective 3—If a student sets up an algebraic equation, they will be able to solve for a given variable and interpret the results.

Conditions of Performance—Given an equation they have set up, students will solve it for the indicated variable.

Criterion—Students will be given an in-class worksheet and homework assignment where they will be given a word phrase or problem and asked to translate it into an algebraic expression or equation. This requires the student to define variables and set up a problem. Once this has been done, the student will solve the algebraic equation and then interpret the results based on the variables they defined when setting up the problem.

1.5 Motivation Analysis

The motivation gaps associated with this analysis are described in the table below:

Motivational Gap	Motivational Strategy
Attention — Due to the age group of the target students, attention span is an important factor to consider. Middle school and high school freshmen aged students are young and 'fidgety' and need more interaction in order to stay engaged in a lesson. Also, because of the verbose nature of the lesson it would be easy for students to become overwhelmed and mentally check out for the remainder of instruction time.	This motivational gap can be addressed by creating a hands on and interactive lesson plan. Based on Keller's ARCS Model, the means of engagement needs to not take too much time or detract from the overall goals of the lesson. Therefore, I believe when discussing the operations and their orders visual aids can be introduced. For example if we discuss how to write 2 less than twice a number, we can let a marble represent our number. The instructor

	can then demonstrate the difference between 2x-2 and 2-2x by using other marbles to show the two quantities are not equal. Also, if the instruction time is to only focus on operations, and their order then a game of identifying key words that indicate each operation (i.e. less indicates subtraction, more indicates addition, etc) can be made up by the instructor.
Confidence — Many students studying mathematics in grade school at some point develop the mentality they that are just not good at math. Thus any concept seeming particularly difficult is ruled out as something that is not worth trying hard to figure out as they assume they won't be able to learn the material. With word problems especially, more critical thinking is involved, and students consider them more difficult. Therefore attitudes and overall morale preceding this lesson might not be positive.	Confidence can be addressed by making sure that the students are given concept check problems during class to work on so that they can be helped along the way as the word phrases increase in difficulty. Another way to address this issue is to break students down into groups. If they work together they will have their work and or questions validated by other students. This will only be effective if the groups are a small size, otherwise some students won't feel the need to do their part within the group. Lastly, positive reinforcement will be essential. Even when students are incorrect they should feel positively about speaking up in class and not discouraged.

1.6 Revisions

Originally the goal steps for achieving the learning outcomes were handwritten in flow chart form. Here they are presented as a flow chart in a word document. It is still my preference to outline the goals for learning outcomes in this way as the train of thought necessary for student success is vivid and clear.

Additionally, the learning objectives 1 and 2 will be broken into two parts, objective 1a/1b and objective 2a/2b respectively The advantages to this, for objective 1 in particular, is that different strategies will be employed to achieve the different parts. For example when determining instructional design it was decided that for objective 1a general strategy of organization and elaboration in the form of word tables was best suited. However, for 1b it would be more advantageous for student learning if a general strategy focused on recall was implemented instead. These decisions will be further clarified in the next portion of this paper.

2 Design

2.1 Instructional Sequence

I believe the sequencing scheme best suited for my instruction is Learning-Related Sequencing proposed by Posner and Strike (1976). This type of sequencing is based on five student learning concepts: identifiable prerequisites, familiarly, difficulty, interest, and development. Translating word phrases or problems into algebraic expressions and equations is a skill that has to be built up from other skills and this approach allows me to do that. In Morrison, Ross, Kalman, and Kemp (2011) Table 6-1 on page 138 describes the five student learning concepts listed above. The Phenomenon and Prescription sections below are taken directly from that table while the example column describes how this sequencing scheme applies to by instruction.

Phenomenon	**Prescription**	**Example**
Identifiable prerequisite	Teach a skill required to perform another skill first	In order to translate a word phrase into an algebraic expression students must first become comfortable with defining variables and also with the language that indicates each of the four operations (addition, subtraction, multiplication, division)
Familiarity	Begin with the most familiar information then progress	Remind the students the difference between an algebraic expression and an equation. Also recap the four operations: addition, subtraction, multiplication, and addition
Difficulty	Teach the less difficult before the more difficult	First we will start with word phrases that lead to expressions involving one operation before working with phrases that involve multiple operations. Finally we will work our way up to equations where you have two expressions with an equals sign in between
Interest	Begin with the topics that will create the most learner interest	I will use word phrases that deal with money and fun real life scenarios before going over examples that are purely algebraic
Development	Ensure that the learner has reached the appropriate developmental level before	The lesson should be a build up of material where we do not move on to more difficult

	teaching a task or topic	concepts until the skills required for it have been mastered

By using the Learning-Related Sequencing scheme I was able to come up with the following instructional timeline. The instruction will take place over three instruction periods. The events of instruction are based on Gagne's Nine Events of Instruction.

Instructional Period 1

Segment	**Duration**	**Event of Instruction**	**Objective and Associated Content**
1	5 min	Inform Learners of Objectives and introduce lesson plan verbally using Chalk/White Board	• Introduction of lesson—Identifying key words in word phrases and problems and the order of operations indicated
2	5 min	Students fill in table on White/Chalk Board with one column for each operation	• Identify the key words students are already familiar with regards to each operation • Instructor includes examples students did not think of
3	5 min	Students make their own table for each of the operations	Materials Key Words Worksheet passed out so that students can make their own table
4	10 min	Key Word Bank Activity	• Students match words from a word bank with the operation they indicate and read phrases and identify operations indicated
5	10 min	Discussion with Students using Chalk/White Board	• Recap the order of operations (PEMDAS) • Give examples of word phrases and identifying the operations and then

			the order they occur in
6	10 min	Order of Operations Activity	Materials Worksheet that makes students identify operations in a word phrase and then indicate the order of these operations

Instructional Period 2

Segment	Duration	Event of Instruction	Objective and Associated Content
1	5 min	Inform Learners of Objectives and introduce lesson plan verbally while using Chalk/White Board	• Introduction of lesson—Translating word phrases and problems into algebraic expressions and equations
2	15 min	Students define variables based on different word phrases and problems on Chalk/White Board with instructor	• Recall how to define a variable • Given a situation, define appropriate variables
3	5 min	Short activity with partner students are given two examples and have to define appropriate variables	Materials Small two problem worksheet with a word phrase and a word problem
4	10 min	Using Chalk/White Board teacher shows through examples how to define a variable and then use it to translate a word problem or phrase into an algebraic expression or equation	Materials Student will follow along with the teachers examples via fill in the blank notes
5	10 min	Algebraic Expressions and Equations Activity	Materials A worksheet will be given out for students to work on where they have to translate 4 phrases/problems into an

			algebraic expression/equation by defining variables and writing expressions with the operations in appropriate order

Instructional Period 3

Segment	Duration	Event of Instruction	Objective and Associated Content
1	5 min	Inform Learners of Objectives and introduce lesson plan verbally and using Chalk/White Board	• Introduction of lesson—Given a word problem students will translate it into an algebraic equation, solve this equation for the define variables, and interpret the results
2	10 min	Equations will be solved at Chalk/White Board	• Solving equations and interpreting results from the previous nights homework assignment
3	15 min	Instructor will give examples of how to solve world problems using all of skills from previous lessons	• Students will learn how to solve word problems and interpret the results
4	15 min	Solving Word Problems Activity	Materials Students will be given a worksheet with word problems that they will have to solve using all of the skills learned in previous two instructional periods and the beginning of the current one

The first instructional period serves as a perquisite to the second instructional period as the students cannot write algebraic expressions without first understanding how to manipulate and recognize the operations involved and the order the wording indicates. After this I incorporate the familiarity learning concept by going over the difference between an algebraic expression and an algebraic equation. From here in instructional period 2 and instructional period 3 the content increases in difficulty level. By breaking the material into three instructional periods I help control mastery of each individual topic. The students will be developing the skill described in the objective at a reasonable pace. Also, by breaking the content into three lessons I avoid flooding the students with too much information and can peak interest in each lesson plan using the materials and activities described in the tables above. Finally, each lesson is designed with 45 minutes of instruction for a 50 minute class to allow flexibility.

2.2 *Instructional Strategies*

Below I will list each objective associated with this instructional design. The strategy for each objective is based on Jonassen's generative strategies as introduced in Morrison and Kemp (Ch. 7). As this is difficult subject matter for most learners, in order to retain the information I chose an instructional strategy I felt would promote deeper learning. It is important to for the students to understand and retain the information from this instruction. I also followed the prescriptions for teaching concepts as highlighted in Morrison and Kemp (Ch.7). Each learning objective is a concept.

Objective 1a

Given a word phrase or problem, students will identify the operations indicated

Strategy—Organization and Elaboration

Initial Presentation—Teacher will create table with key words and the operations they indicate with assistance from students

Generative Strategy—Students will create their own key word table and complete word bank activity where they are given a word bank and have to categorize each word according to the operation it indicates Worksheet that makes students identify operations in a word phrase and then indicate the order of these operations

Objective 1b

Given a word phrase or problem, after identifying operations indicated, students will determine the order of the operations

Strategy—Recall and Integration

Initial Presentation—Students will recall PEMDAS and then be given several examples of how to determine the order of operations in a word phrase or problem

Generative Strategy—Students will be given a worksheet where they will be given word phrases and will have to indicate the order of operations

Objective 2a/b

Given a word phrase or problem, students will be able to define variables and translate it into an algebraic expression or equation

Strategy—Recall and Integration

Initial Presentation—Students will be provided with examples of how to define variables and then how to use these variables to create an algebraic expression or equation

Generative Strategy—Students will work in groups to view word phrases and problems and define appropriate variables. After this activity, students will play a game where it will be necessary to translate word phrases and problems into algebraic expressions or equations

Objective 3

Given a word problem, students will be able to translate it into an algebraic equation, solve the equation for the indicated variable, and interpret the results

Strategy—Recall and Integration

Initial Presentation—Students will be provided with examples of how to solve an algebraic equation and interpret results based on the variables defined

Generative Strategy—Students will work on groups to translate word problems into algebraic equations, solve these equations, and interpret the results

2.3 Instructional Activities

As previously stated, this instruction is designed with the intent to be covered over three different instructional periods. Each instructional period has a unique objective and activities within that instructional time to help meet said objectives. The following details the activities associated with each period.

Instructional Period 1: Objectives 1a and 1b

Key Word Chart—With a partner students will create their own key word tables where they make a column for each operation and then in each column identify key words that indicate that operation. This table will be a more comprehensive version of the table that is made by the instructor. This table will serve as a reference for the remaining instructional periods.

Order of Operations Activity—Students will be given a worksheet where they identify operations in a word phrase and then indicate the order of these operations

Homework—Student will be given a homework assignment that includes a two challenge questions along with five questions that sample those questions seen in the worksheets completed in class

Instructional Period 2: Objective 2

Define Variables Activity—With a partner students will be given a worksheet with a word phrase and a word problem and will have to define variables in each case and confirm these results with the rest of the class

Interactive Notes—As the instructor goes over examples of how to translate word problems and phrases into algebraic equations and expressions students will follow along with fill in the blank notes so as to not waste time write down every scenario. This should encourage students not to zone out or get behind with note taking because they are taking to long to write down a particular word phrase

Algebraic Expressions and Equations Activity—This worksheet will help students work on their own translating word problems/phrases into algebraic equations/expressions. The instructor should take this time to go around and give help where it is needed

Homework—Students will be given a five questions homework assignment similar to the worksheet questions given in class with a bonus challenge question

Instructional Period 3: Objective 3

Solving Word Problems Activity—This is the most important worksheet of all those that have been administered thus far. Students will be given a worksheet with word problems that they will have to solve using all of the skills learned in previous two instructional periods and the beginning of the current one. First they will have to read a word problem, identify key words and the order of the operations indicated. They will then use this to write an algebraic equation with defined variables. Then they will solve this equation and interpret the results based on the variables that were defined.

Homework—Students will be given a five question homework assignment similar to the worksheet questions given in class with a bonus challenge question

General Activities

Quiz/Exam: At some point there will be a unit exam where these materials will be tested. There will also be a quiz testing this material specifically.

2.4 Design Considerations for Instructional Content and Materials

Below is a table that explains the materials needed for each objective of this instruction. As this will be taught in a very traditional classroom set up the needs are minimalistic. Outside of the visual aids (marbles, money, candy) that will be used in

Objective 2 everything else will only require students taking notes and working on in-class worksheets and homework assignments which will be created with Microsoft word. Thus for students, all that is necessary is notebook paper and a writing utensil. For instructor it is necessary to have access to a word processor, printer, and/or copier

Objective	Instructor Materials	Student Materials	Format
1a) Given a word phrase or problem, students will identify the operations indicated	*Lesson Outline *Homework Worksheet Key	*Key Word Table *Homework Worksheet	*White/Chalk Board *Word Document(s)
1b) Given a word phrase or problem, after identifying operations indicated, students will identify the order of the operations	*Lesson Outline *In-Class Worksheet Key *Homework Worksheet Key	*In-class Worksheet *Homework Worksheet	*White/Chalk Board *Word Document(s)
2) Given a word phrase or problem, students will be able to define variables and translate it into an algebraic expression or equation	*Lesson Outline *In-Class Worksheet Key ***Homework Worksheet Key**	*In-class Worksheet ***Homework Worksheet**	*White/Chalk Board *Visual Aids *Word/Documents
3) Given a word problem, students will be able to translate it into an algebraic equation, solve the	*Lesson Outline *In-Class Worksheet Key *Homework Worksheet Key	*In-class Worksheet *Homework Worksheet	*White/Chalk Board *Word/Documents

equation for the indicated variable, and interpret the results			

Note that in the above table the items in bold blue are those materials developed for the instructor and the student for this particular assignment.

As the primary source of instruction is a lecture format, albeit interactive, fill in the blank notes will be created to increase attention and promote active engagement. Each in-class worksheet is meant to increase understanding and also to reiterate Learning Based Sequencing by Posner and Strike (1976) by building the conceptual instruction up one piece at a time so as not to overwhelm the learners.

2.5 Motivational Strategies

There were several motivational strategies I considered when designing this instruction. As a pre-instructional strategy I decided to provide an overview of each class objective as I assume that the learners will be mostly lower-ability students and higher ability students without a lot of in between. I also believe in math classes it is important to alert students consistently of the big picture and it helps serve to make a framework for how the class will be organized.

The activities planned for the students were designed with Keller's ARCS Model of Motivational Design in mind. Due to the age of the learners and the assumption that most students do not feel as if they are good in math, I most heavily focused on Attention

and Confidence from the ARCS Model when designing the instruction. The beginning of each instructional period involves introducing the objective and then the instructor interacting with the students to generate discussion about the first topic of the day. Requiring student participation from the onset highlights the 'inquiry arousal' component of attention based motivation. The examples given by the instructor will help with concreteness of the material.

There are several worksheets along with homework assignments incorporated into each instructional period. These align with the Confidence motivational strategy as they encourage students to think by themselves and with their peers about a problem, as opposed to being consistently guided by the teacher throughout the entire instructional period. The goal of in class worksheets is also to facilitate independent learning and thinking about more challenging material, so that when it comes time to complete the homework students are more likely to not give up if they get confused but keep working through a problem until it is correct.

2.6 Revisions

For learning objective 1 it was determined that having students create their own key word table after creating one with the instructor at the white/chalk board is redundant. Also, having a key word activity *after* creating a table with the instructor is also a bit redundant. Instead the in Instruction Period 1 Segments 2-4 will be combined for a total of 20 minutes and Segments 5,6 and six will remain the same except that they will now be 3 and 4. So in Segment 2 students will now interact with the instructor to

begin a key word table on the white/chalk board. After a couple of examples are listed the instructor will create a word bank on the board and ask students to work in groups to classify which words is associated with a particular operation. Then the class will discuss the results together.

In Instructional Period 2, it is stated that two in-class worksheets will be given. Instead, after the first worksheet is completed the rest of the class will follow a lecture format. The second worksheet will be worked into the examples presented in class. This decision was made to cut out the second worksheet because it took away from the amount of time allotted to understand how to translate word phrases and equations into algebraic expressions and equations. The homework will evaluate student learning so the worksheet is not necessary.

3 Project Evaluation

3.1 Purpose of Evaluation

The most appropriate type of formative evaluation for this instruction is a Connoisseur-Based Study, a term employed by Morrison, Ross, Kalman & Kemp (2013). I will consult with Dr. Kyong Mi Choi an Assistant Professor of Mathematics Education at the University of Iowa in the Department of Teaching and Learning. After she reviews the instruction and all relevant materials of the project I will ask that she respond to a questionnaire. The questionnaire will address each of the questions below. Note that each

aligns with a criterion that is necessary to collect in a Connoisseur-Based study (Morrison, et al.) as indicated by parenthesis.

1. Do the homework worksheets and in-class activities accurately reflect the learning objectives for instruction? (Overall effectiveness of the instruction)
2. Is the instructional sequencing efficient? Is the pacing realistic? (Organization and Flow)
3. Is the instructional design easy to follow? (Readability)
4. Are there potential sources of confusion based on the methods employed to achieve the learning outcomes? (Representation of Current Best Practice)
5. Are there any errors in the instructional materials? (Accuracy of Content)

3.2 Description of the Evaluation Plan

Few resources will be required to conduct this formative evaluation outside of a classroom setting conducive to group work, a white board, chalk board, and/or projector, and access to a printer and/or copier. This is all that will be necessary to gather the necessary data. Within the proposed instruction, different learning objectives will require different data-gathering techniques. Each of the techniques outlined below are based on those outlined in Chapter 11 of *Designing Effective Instruction* by Morrison, Ross, Kalman, Kemp (2013).

Objective 1a—Given a word phrase or problem, students will identify the operations indicated

In order to evaluate this learning outcome an objective test will be used, particularly a matching test. This is an ideal assessment for this cognitive skill. A multiple-choice test could also have been chosen but runs the risk of feeling too 'formal' for an in-class assessment. Before completing this evaluation students will create a word bank of different key words that indicate the four operations. The matching test will require students to identify keys words with their indicated operation in a method similar to the line of thinking required to create the aforementioned word bank. This assessment is simple to check for accuracy and will give the instructor insight during the lesson as to whether learning is occurring. The data from this assessment will be used to determine if the students collectively are ready to continue forward with the proposed instruction.

Objective 1b—Given a word phrase or problem, after identifying operations indicated, students will determine the order of the operations

Rather than using an objective test, this learning outcome is best evaluated by a constructive-response test. Students will be given a fill in the blank worksheet where they are to indicate the order of operations present for a series of word phrases or problems. Requiring the fill in the blank to only be used to write the order of operations shifts the focus on the key words and the operations they indicate to the order which is the purpose

of this learning outcome. The data will be used to determine if it is appropriate for the instructor to proceed or if further review and or examples are necessary.

Objective 2—Given a word phrase or problem, students will be able to translate it into an algebraic expression or equation

In evaluating objective 2 a constructive-response test will be used. In particular, the assessment will focus on problem solving questions as that is best suited for the cognitive skills necessary to define variables and set up algebraic expressions and equations. First the questions will require students to define variables for a series of word problems and equations. Next students will use these variables to translate word phrases and problems into algebraic expressions and equations in an open response type format. The data will be used to determine if this skill has been acquired before moving on. If there is a pattern of confusion the previous lesson should be expanded upon for an extra instructional period and then revised for future students.

Objective 3—Given a word problem, students will be able to translate it into an algebraic equation, solve the equation for the indicated variable, and interpret the results

This learning outcome will be assessed with a multiple choice assignment. This was chosen because of the subjectivity of how students might interpret the solutions of their equations. Having a multiple choice assessment allows the student to check to see if the answers are accurate quickly and also allows for guidance on how solutions to word

problems should be worded. It also provides the instructor with a simple way to check student work at the beginning of the subsequent instructional period to determine if further review is necessary.

3.3 Evaluation Implementation Plan

As previously mentioned the formative evaluation will be conducted by Dr. Kyong Mi Choi, an Assistant Professor of Mathematics Education at the University of Iowa in the Department of Teaching and Learning. The evaluation questionnaire will be sent to her on January 1, 2016, along with the complete instructional design and all of the evaluation materials (worksheets, quiz, etc.). On February 1, 2016 Dr. Kyong Mi Choi will return the completed evaluation questionnaire and previously submitted materials. Two weeks later on Feb. 15, 2016 at 12:00pm we will meet in a reserved room at the University of Iowa Main Library. At this time I will have had time to review her questionnaire and any additional notes she has made. We will meet for 2 hours to discuss any questions I may have on her evaluation, any changes I should make, and general strategies for instructional design for this type of topic with young students.

3.4 Revisions

Originally, when evaluating Objective 2, a provision was made for what was called Objective 2a which required students to first practice skills defining variables before addressing the actual objective. This particular skill is better classified as an entry

behavior or a subordinate skill. If it is not in general, then the worksheet will serve the purpose of introducing students to defining variables. Other entry behaviors such as solving simple algebraic equations, understanding what an expression is, etc. will not be accounted for with a worksheet strictly dedicated to making sure they are understood. The other entry level behaviors will simply be reflected into student ability to acquire the proposed skills each instructional period.

In addition to the evaluation materials previously included for each learning objective a quiz over all three learning objectives was included. It uses a combination of all techniques seen in the previously designed evaluations such as multiple choice, fill in the blank, and open response type questions. Thus there are elements of both objective and constructive-response assessments. It is included in the Appendix. Lastly, the evaluation assessment for learning objective 2, a homework assignment, has been modified to include some less technical questions. Changes have been made in red. This can also be found in the appendix.

Reflection

As a pure mathematician primarily focused on commutative algebra, I spend most of my days in an abstract world. I study abstract algebraic structures and the relationships between them, and since I am not a part of the applied math program, I have been trained to give little thought as to the real world implications of what I am studying. For most pure mathematicians, because of the critical thinking skills, self-discipline, and independent study skills required to be successful in our program, it is hard to relate to

our students. In general they view mathematics as a burden while we have chosen it as a career path, their critical thinking skills are still being polished, and we are often critical of the amount of effort they put forth. This presents a challenge in the classroom.

Earlier this semester before I had spent a considerable amount of time on this instruction, there was very little design process involved in my lesson planning. I assumed that students would come to class caught up with the lecture, current with the online homework, and with questions of their own. There were some concepts I did not feel the need to cover in detail because in my opinion they were too simple to warrant a chunk of class time. In short, while I did my care, my approach to teaching was flawed in that it glossed over or completed disregarded every design decision considered in the making of this instruction.

Identifying learning objectives for lessons plans helped me begin to better structure things in my classroom. It helped to make more effective quizzes, worksheets, and pick out more appropriate example problems. Due to my interest in the subject, it is tempting to stray in class and present things that I find ‘interesting’ but if that doesn’t serve to motivate the students, it’s actually a pretty selfish move. It is me focusing on material that I am intrigued by, even at the expense of student confusion and approaching something too advanced too fast.

Because of my tendency to approach difficult concepts too quickly, the most important thing I have taken away from the design of this instruction is the concept of instructional sequencing. Even if you are a wonderful lecturer, have wonderful worksheets and activities for students to complete, it will all fall apart if the instructional material in not present in an efficient manner. The Learning-Related Sequencing

proposed by Posner and Strike (1976) that was implemented in this design was chosen because it embodies what I believe is the best way to approach teaching mathematical concepts which are highly cognitive. Within this design I used a flow chart to illustrate the goal steps for the learning outcomes; now I sometimes find myself jotting down on scratch paper small flow charts when I am determining the best way to explain word problems to students.

This process forces me to go back and think about what all is involved in the learning process if you are starting from scratch. The importance of this cannot be understated. As aforementioned, I live in an abstract world, and for anything elementary I can usually approach the problem from a point of view much more theoretical than is necessary for the scope of the classes I teach. Now I have learned to truly think about subordinate skills and how students should think about problems based on what they have learned from the large lecture and their textbooks. As an aside, this has also helped make me a better private tutor for middle and high school students, as they require very elementary explanations and methodically organized explanations.

In conclusion, this entire process has really shifted my point of view as a math instructor. There were a lot of mistakes being made that I was unaware of, and now that I am, I can begin to remedy them. I can also impart this knowledge to my classmates. My career goal is to become a teacher at a small liberal arts university. Though I have attended trainings and workshops I have never learned more than I have when completing this instructional design. I will continue to use what I have learned to become a more efficient educator.

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APPENDIX

Evaluation Instruments

Objective 1a—matching worksheet

Directions: For each of the following word phrases or word problems below, circle the key words that indicate an operation. Then match each key word with the operation it represents. Use an 'X' for multiplication, '÷' for division, '-' for subtraction, and '+' for addition.

1) Two more than nineteen _____

2) The quotient of a twenty-eight and seven _____

3) Eighteen less than thirty-three _____

4) Twice as many boys as girls _____

5) The price of the sweater is reduced by $18.00 plus the cost of sales tax. _____

Objective 1b—fill-in the blank worksheet

Directions: For each of the following word phrases or word problems below indicate to the right of the problem the order of the operations present. Use an 'X' for multiplication, '÷' for division, '-' for subtraction, and '+' for addition.

1.) Five less three times a number _____

2.) Three cookies are taken from the package and then the rest of the cookies are split amongst ten people _____

3.) Twelve is sixteen more than four times a number _____

Objective 2—problem solving questions worksheets

Directions: For each of the following word phrases or word problems below define a variable that will help you write translate it into an expression or equation.

1) Five less than four times a number is fifty-three.

2) Each piece of candy costs 25 cents. How much candy can Sandy buy with $2.00?

3) The quotient of thirty-nine and a number is three.

4) Suzanne took Legos out of the box to make a house. There are now 128 Legos left in the box. If the box originally contained 350 pieces how many Legos did Suzanne use for her house?

Objective 3—multiple choice worksheet

Writing Expressions and Equations HOMEWORK

Name : _____ Date : _____

For each of the following translate the word phrase into an algebraic expression and write it into the blank. Use any variable you like!

1) The sum of a number and 18 _____

2) There are three less watches on display _____

3) Four more than twice a number _____

4) Two pizzas are divided amongst ten students _____

5) The quotient of a number and eighteen _____

For each of the following translate the word problem into an algebraic equation and write it into the blank. Use any variable you like!

6) The sum of a number and four is equal to three times that number _____

7) Sarah had to share her markers with four friends and everyone got two. _____

8) Four times three more than a number is six _____

9) A number decreased by fifteen equals twice the sum of eight and a number _____

10) At half price the Christmas sweater is $18. How much is it a full price? _____

Writing Expressions and Equations HOMEWORK
Instructor's Notes

- Note that while the answer key uses the variable *x* consistently the students may choose any variable they like

- Since addition is commutative there are other answer options for several questions as follows:
  1) $x+18$ OR $18+x$
  4) $6x+7$ OR $7+6x$
  6) $x+4=3x$ OR $4+x=3x$
  8) $4(x+3)=6$ OR $4(3+x)=6$
  9) $x-15=2(x+8)$ OR $x-15=2(8+x)$

- Check this homework assignment for completion at the beginning of the next instructional period. Then put students into small groups and have them compare answers. Allow each group to come to a consensus on the correct answers. Walk around and answer questions and note common missed responses if any. Then go over each answer as a class having students read the correct answers out loud.

- If necessary do more examples of the types of problems given on the HW if the students had a hard time completing the assignment accurately. The most common mistakes will involve using parenthesis correctly (eg. Four times the sum of a number and eight should be $4(x+8)$ and NOT $4x+8$) and using the correct order of operations with subtraction (eg. Three less than a number should be $x-3$ and NOT $3-x$)

- For the next topic of solving word equations after translating start with 6) through 10) from the HW as examples and solve for the variable

Directions: For each of the following below choose the best response.

1.) Melanie made $17 doing chores around the house. How much more money does she need to buy a pair of tennis shoes that costs $42?
   a. She needs $2.47 more
   b. She needs $25 more
   c. She needs $30 more
   d. She needs $59 more

2.) Twice a number, decreased by twenty-nine, is seven. What is the number?
   a. The number is 7.5
   b. The number is 11
   c. The number is 18
   d. The number is 22

3.) A large pizza with 15 slices is shared among p students so that each student gets 3 slices. How many students must there be?
   a. There are 5 students
   b. There are 12 students
   c. There are 30 students
   d. There are 45 students.

4.) Collin is x years old. In thirteen years he will be twenty-four years old. How old is Collin right now?
   a. Collin is 8 years old.
   b. Collin is 11 years old.
   c. Collin is 25 years old.
   d. Collin is 37 years old.

5.) Thirty-two is three times a number increased by eight. What is the number?
   a. The number is -8.
   b. The number is 8/3.
   c. The number is 5.
   d. The number is 8.

Objectives 1-3—Unit Quiz

Quiz

Name: _____ Date: _____

1) Consider the word phrase: "15 less than the sum of a number and 80." Which of the following best describes this translated into an algebraic expression?
   a. 15-x+80
   b. 15-(x+80)
   c. (x+80)-15
   d. (80+x)-15
   e. both a and b
   f. both c and d

2) Translate "The quotient of four times a number and three is twelve" into an algebraic equation. Write your answer in the blank below.

   _____

3) A package of oreo cookies is shared by five friends and everyone gets fifteen cookies. Write an equation that represents how many cookies must be in the package. Write your answer in the blank below.

   _____

4) Suppose Jerry is *x* years old. Karen is eight times older than Jerry and Alice is ten years older than three times Jerry's age. Suppose Karen and Alice are the same age. How old is Karen?
   a. 1 years old
   b. 2 years old
   c. 15 years old
   d. 16 years old