A Worked Example Design with ARCS Motivational Model

Eva Julianingsih[1,a)], Endah Retnowati[2#,b)], Khar Thoe Ng[3,c)]

[1,2#] Department of Mathematics Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Indonesia.

[3] Training and Research Division, SEAMEO RECSAM, Penang, Malaysia

Author's Emails
[#,b)]corresponding author <e.retno@uny.ac.id>
[a)]evajulianingsih0@gmail.com, [c)]postgradtask@gmail.com

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Abstract

Purpose and Research Question - This paper aims to depict the development of a study worksheet that integrates the ARCS model with the worked example method in learning trigonometry.

Methodology - The Design and Development Research (DDR) and cycles of reflective practices (improvement was made based on feedback in the preliminary phase) are the methodologies integrating ARCS instructional model that categorizes four essential strategies (i.e. '**A**ttention, **R**elevance, **C**onfidence, '**S**atisfaction') in designing learning that can increase and maintain student motivation. The authors started by drafting worked example that is one of the learning methods recommended by cognitive load theory which is usually used in teaching students about complex problems. The purpose of worked example method is to minimize extraneous cognitive load of students when working on complex questions.

Findings/Discussions - The analysis of DDR processes with two cycles of reflective studies that were implemented revealed that an 'Analysis, Design and 'Develop' (ADD) procedure was used as a research framework in developing the worksheet. These involved: 1) **A**nalysis of the learning material; 2) **D**esign a worked example and validate the solution steps whether cause extraneous cognitive load or lot; 3) **D**evelop into several pairs of 'problem 'solving' examples supported that integration of ARCS model to assist learning.

Significance and Contribution in Line with Philosophy of LSM Journal – The results of this study provide mathematics teachers with the study worksheet model for teaching trigonometry with a lower extraneous cognitive load but higher intrinsic cognitive load from the motivation factor.

Keywords: *ARCS, Cognitive load; Motivation; Trigonometry; Worked example*

Introduction

Undoubtedly, a basic psychological factor that students in the learning process need is motivation. The learning motivation of each student in a class must be varied as many aspects of learning environment may influence it. Motivation is an internal state that encourages, arouses and directs a person to achieve specific goals, such as needs or interests (Woolfolk, 2016). For instance, a student will be encouraged to learn mathematics when the student has an interest in patterns of numbers. It is greatly suggested that methods that can be used to stimulate students' interest in learning mathematics should always be developed.

Motivation consists of two categories: intrinsic motivation and extrinsic motivation.Intrinsic motivation is the motivation that arises from oneself, while extrinsic motivation is the motivation that occurs because things outside the individual trigger it. A teacher might be able to encourage the emergence of intrinsic motivation in students and ensure that extrinsic motivation supports learning (Brophy, 2004; Deci & Ryan, 2000). Extrinsic motivation might be stimulated by teachers by giving gifts (rewards) as a consequence of certain behaviors (Del Soldato, 1992; Woolfolk, 2016). Prizes here can be in the form of grades, praise, or objects given to students. Some people like to experience accomplishments that increase their feelings of self-worth, experience positive interactions with others, have their views heard and respected, and master challenges that increase their feelings of competence (Keller, 2010), including when learning mathematics. All these things can motivate individual students to have an interest in learning mathematics.

ARCS Model is an approach developed by an educational psychologist, John M. Keller, who aims to design aspects of motivation and learning environment to encourage and maintain student motivation to learn. The ARCS model is a framework for designing motivational learning that incorporates motivational concepts and theories (Asiksoy & Özdamli, 2016; Li & Keller, 2018; Turel & Ozer Sanal, 2018). This model is divided into four categories: Attention, Relevance, Confidence, and Satisfaction. According to Keller, ARCS-based learning is a form of problem-solving approach to zemphasize motivation and create a learning environment in encouraging and maintaining student motivation to learn. The success of learning mathematics is not only because it can understand concepts and theorems and then apply them but also because of the will, attitudes and other motivations. The ARCS model can effectively boost learners' intrinsic motivation by recognizing that they are capable of learning and can determine themselves (Feng & Tuan, 2005). The following describes each category of ARCS as explained by Keller (2010).

The first category, attention, contains motivational variables that stimulate and maintain students' curiosity and interest. In the context of learning, attention here is how to manage and direct students' attention. This may be done by using cues and prompts to require students to focus on the stimulus or part of the inspiration that is specifically related to the learning objectives. Before attention can be directed, it must be obtained, which occurs in the realm of motivation. Therefore, motivational attention is getting and maintaining attention (Keller, 2010).

The second category, relevance, ensures that students believe the learning experience is personally relevant. Students may ask the classic question, "Why should I study this? It doesn't apply to my field?". From the sample questions, the students did not feel personal relevance to the learning material. According to Keller, before students can be motivated to learn, they must believe that the instruction is related to an important personal goal or motive and feel connected to the setting (Keller, 2010).

Even if students believe that the material is relevant and they are curious to learn it, they may still not be adequately motivated because of too little confidence or hope for success, hence the third category, confidence. Learners may have intense fears about topics, skills, or situations that prevent them from learning effectively. On the other hand, they may mistakenly believe they already know it and ignore essential details in the learning activity.

If a teacher succeeds in achieving these first three motivational goals (attention, relevance, and self-confidence), students will be motivated to learn. Moreover, the fourth category, satisfaction, sustains 'students' desire to continue learning. In other words, they must feel satisfied with the process or result of the learning experience. Satisfaction can be generated from extrinsic and intrinsic factors. Table 1 reproduces the ARCS Model in brief descriptions.

Tabel 1 ARCS Model Categories (Keller, 2010)

Major Categories	Description	Process Questions
Attention	Capturing the interest of learners; stimulating the curiosity to learn	How can I make this learning experience stimulating and interesting?
Relevance	Meeting the personal needs/goals of the learner to effect a positive attitude	In what ways will this learning experience be valuable for my students?
Confidence	Helping the learners believe/feel that they will succeed and control their success	How can I via instruction help the students succeed and allow them to control their success?
Satisfaction	Reinforcing accomplishment with rewards (internal and external)	What can I do to help the students feel good about their experience and desire to continue learning?

The ARCS can be seen as an instructional design of motivational steps. The dimensions contained in the ARCS model support the occurrence of motivation in individuals. Each of the four categories also has sub-categories based on the major motivational variables subsumed by the categories (Table 2).

Table 2 Subcategories of ARCS Model (Keller, 2010)

Attention	Relevance	Confidence	Satisfaction
Perceptual Arousal Provide novelty and surprise	Goal Orientation Present objectives and useful purpose of instruction and specific methods for successful achievement	Learning Requirements Inform students about learning and performance requirements and assessment criteria	Instrinsic Reinforcement Encourage and support instrinsic enjoyment of the learning experience
Inquiry Arousal Stimulate curiosity by posing questions or problems to solve	Motive Matching Match objectives to student needs and motives	Successful Opportunities Provide challenging and meaningful opportunities for successful learning	Extrinsic Reward Provide positive reinforcement and motivational feedback
Variability Incorporate a range of methods and media to meet 'students' varying needs	Familiarity Present content in ways that are understandable and that related to 'learners' experiences and values	Pesonal Responsibility Link learning success to 'students' personal effort and ability	Equity Maintain consistent standards and consequences for success

Nowadays, mathematics learning is often problem-solving oriented. Mathematics problems are presented as the core methods of instruction (Glogger-Frey et al., 2015a, 2022; Schmidt et al., 1989; Schwartz & Bransford, 1998), mostly in the form of a word or story problem. When the learner is required to find complex problem solutions, learning by discovery or problem solving can have drawbacks (Sweller et al., 2007). Learners without sufficient prior knowledge could experience extraneous cognitive load because of the random search of the knowledge base in their working memory while attempting to solve the given problem. In this condition, explicit guidance, such as a worked example, has been suggested (Ashman et al., 2020; Glogger-Frey et al., 2015b; Newman & DeCaro, 2019; Roelle & Berthold, 2016). The worked example could assist learners in acquiring new knowledge of solving problems more efficiently. The worked example has been shown as a learning strategy to minimize the effect of cognitive load due to the presentation of complex material (Ayres & Sweller, 2005). It provides stages of learning that might not impose a cognitive load on students when solving subsequent problems. Presentation of material through worked examples makes it easier for novice students to use cognitive resources in recognizing, remembering, and understanding problem structures and their solutions according to demonstrations from examples (Cooper, 1990). Therefore, in addition to motivation, the presentation of the learning material also matters.

The working example models the problem-solving process by presenting an analog or isophormic problem and showing the steps required to lead to a final answer. The effectiveness of the worked example is believed to be due to the elaborated examples phase in which several examples are presented before students are expected to engage in problem-solving themselves (Atkinson et al., 2003). The cognitive load theorists use three worked example methods, namely, in full (worked examples) or partially (completion problems) (Van Merriënboer & Sweller, 2005). This is intended so that students have a gradual picture of how to solve new and complex problems. Studying worked-example in the early stages of cognitive ability acquisition can result in a deeper and more meaningful understanding of problem-solving procedures for beginners (Kalyuga, 2011).

The most important to take into account is that the presentation of the worked examples does not cause extraneous cognitive load (Atkinson et al., 2003). This load occurs when the elements in the problem solutions create split attention or redundancy effects (Ayres & Sweller , 2013). This study aimed to design worked examples that do not cause extraneous cognitive load while integrating the ARCS method, using a mathematics topic learned at most high schools. The designed worked example will be identified as containing the ARCS motivation method. Therefore, this design is expected to stimulate more motivation when novice learners studying worked examples.

Research Methodology

Research Design

The 'Design and Development 'Research' (DDR) is the research design implemented through cycles of designing particular (i.e.' 'mathematics' in this study) lesson exemplar undergoing 'specific project phases involving 'evaluation' of 'product & tool 'research' of DDR (Richey & Klein, 2007, p. 8). Cycles of reflective practices were also involved integrating ARCS instructional model that categorizes four essential strategies, including '**A**ttention, **R**elevance, **C**onfidence, '**S**atisfaction' (ARCS) in designing 'instructional system 'design' (ISD) product (Ragan & Smith, 2004 in Richey & Klein, 2007, p. 27). In the case of this study, the mathematics learning lesson exemplar is the ISD product aiming to increase and maintain student motivation supported by the ARCS model anchoring on motivation theories. Teaching and learning activities with evidence-based findings were implemented with the management of the overall design process (Ragan & Smith, 2004 in Richey & Klein, 2014), including evaluation activities involving examination of worked examples as illustrated in this study.

Research Process

The instructional product in this study was developed following the three steps of instructional model development, including Analysis, Design and Development (Branch, 2009). The researcher designed a worked example integrated with the ARCS motivation model at the design stage. This design aims to reduce or eliminate extraneous cognitive load and apply the ARCS model to maintain or increase student motivation. Some motivational tactics and analysis of the appropriate treatment to increase and maintain student motivation during the learning process of the worked example. At the development stage, the researcher creates pairs of worked examples that students must learn and understand by paying attention to aspects that affect the increase in extraneous cognitive load, such as split attention or redundancy, as well as the content of the paired problem-solving that students must solve after studying the examples. The product that has been prepared is then tried-out and consulted with a team of researchers to determine whether the worked example pairs contain word problems, isomorphic problems, step-by-step solutions and have the minimum extraneous cognitive load.

Results

The following are the steps in designing a worked example with the ARCS model of motivation.

Analysis

Trigonometry was selected in this study, targeted for novices at the senior high school level. Due to this material is not easy for students to understand, not only because trigonometry is abstract, procedural, and symbolics, but also it is considered new for the targetted learners. This material contains applying some mathematical concepts such as the Pythagorean theorem, proportion, and angles, as well as the concept of trigonometry itself. Sufficient prior knowledge is required in order to follow the application of trigonometry to solve contextual problems. The level of prior knowledge determines the level of expertise. For more knowledgeable learners, the level of element interactivity in a learning material can be simplified, therefore lowering the intrinsic cognitive load; and vice versa. Consequently, in using the worked example, the learners level of prior knowledge must also be considered (Darejeh et al., 2021; Sentz et al., 2019).

Design

In this study, worked example is integrated with ARCS model. The design begins with determining the context of the trigonometry problem to be used in the draft of study worksheet by using the principle of "Relevance" to connect the problem with students' daily lives. The problems used are problems with high element interactivity, it means there are presumably more than seven chunk of elements in the problem solving to be learned by students (Kalyuga, 2011). The main goal of learning is to determine distance of two points which can be illustrated as one of the side lengths of a triangle. Students must use several related concepts that have been studied previously to achieve the learning goal with a managed intrinsic cognitive load. These are the 'Pythagoras' theorem, proportions, angle measures, and basic trigonometry ratios. Therefore, word problems were created. Word problems tell a context that should be chosen according to the familiarity of the learner. For example, agricultural-related problems might be more relevant for vocational high schoolers majoring in Agriculture than those in arts.

To direct students' attention, motivational statements were written at the beginning of the study worksheet as question instructions. Appropriate motivational statements were chosen to foster students' self-confidence. Students were instructed to read the statement before learning the worked example or solving the paired problem. By this design, students are expected to raise their satisfaction and confidence in doing mathematics.

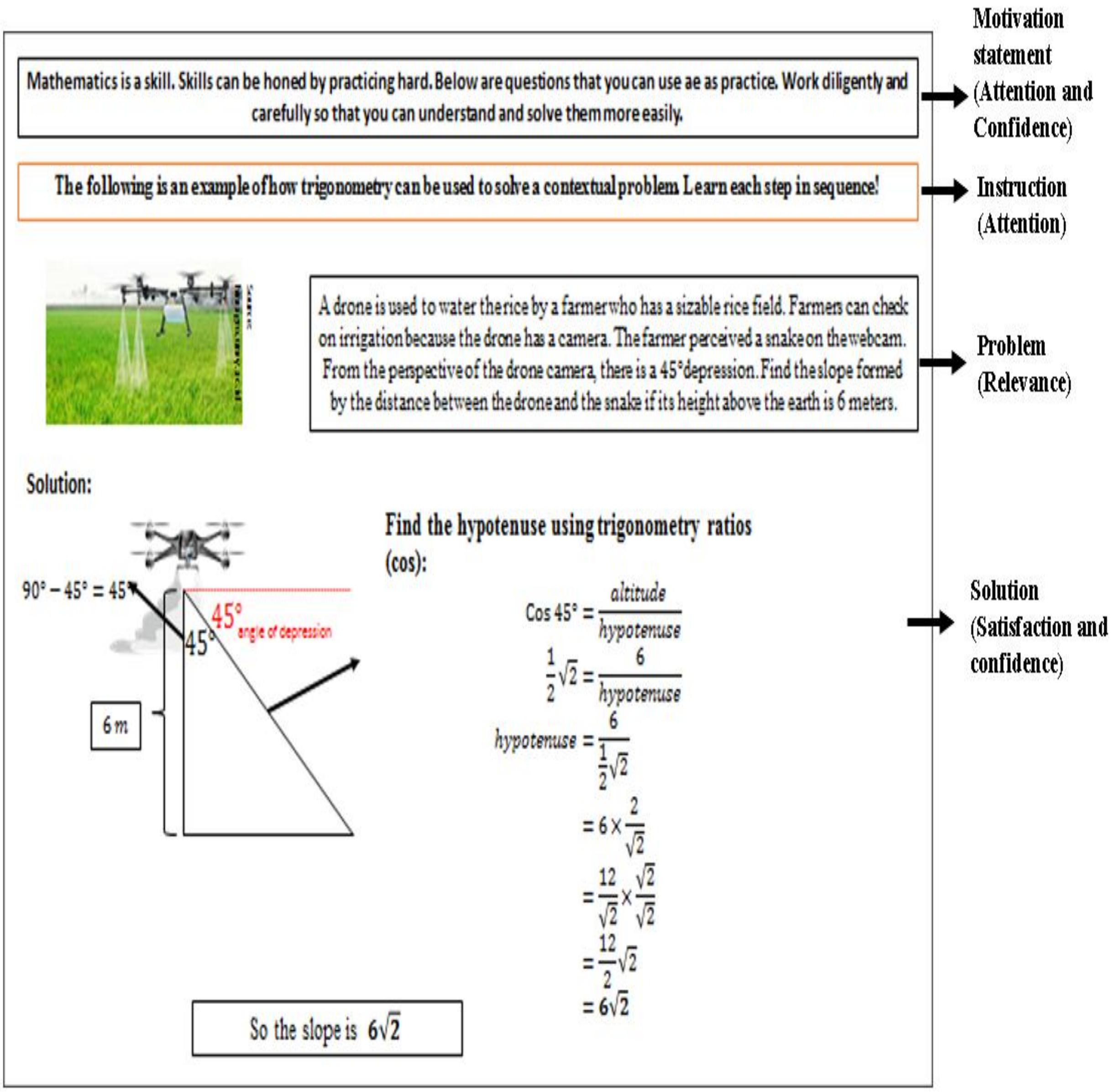
This design uses a worked example - problem solving pairs design. Students were provided worked examples first and continued solving paired problems similar in context and procedure. In other words, the pairs have the same solution structure although the context of the word problems are different. By this way, the worked example can be used to acquire the new concept, and the paired problem can be used as a practice problem. The practice should be given directly after the example in order to facilitate mental rehearsal and so, understanding.

Trigonometry may require multi-step solutions and illustrations to assist learning in abstracting the contextual problem into mathematics symbols. The design is that the text is placed near the picture to be explained by the text to avoid the split attention effect. The designers should ensure that the text does not cause redundancy and that the multi-step are clearly indicated. Accordingly, students can accomplish the cognitive process with a managed load of thinking.

Development

The following Figure 1 is an example of the developed worked example, followed by the problem that students must solve without seeing the worked example (Figure 2).

Figure 1 Worked example of depression angle problem (arrows on the right are added for pointing the segments of ARCS)



The worked examples contain A (Attention), R (Relevance), S (Satisfaction), as indicated by the arrow on the right of Figure 1. The given segment on S is argued to create the C (Confidence) since the solution steps are designed to minimize extraneous cognitive load to facilitate effective knowledge acquisition. The overall ARCS in the worked example could create motivation to engage in learning the following problem solving. The paired problems of the worked example shown in Figure 2 only contain the instruction and problem to solve. The context is the same, agriculture. The structure of the problem is also the same, which requires the trigonometry of cosine. This pairing is meant to allow learning to rehearse and obtain a deeper understanding of the acquired knowledge from the worked example.

Figure 2 The paired worked example of the depression angle problem (arrows on the right are added for pointing the segments)

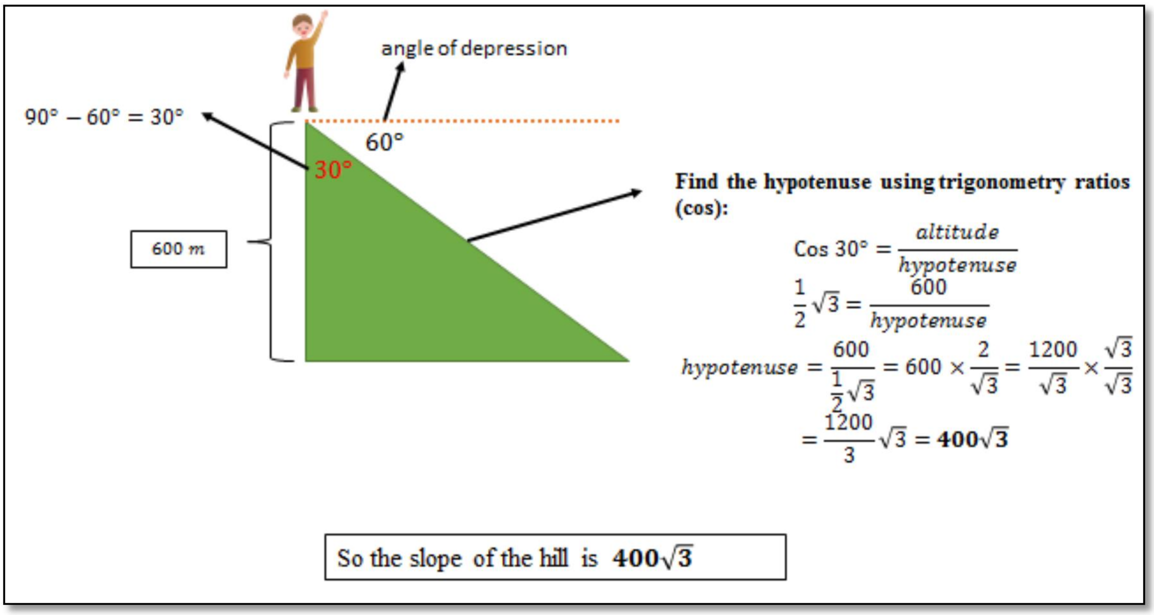
The following is a contextual trigonometry problems. Do it according to the steps as in the previous example in order!	→ **Instruction (Attention)**

To reduce the risk of erosion and landslides, a farmer with land on a hill with a steep slope will plant oil palm using the Sloping Agriculture Land Technology (SALT) method. Farmers want to know the slope of the land ahead of time. The farmer stands at the top of a hill with a 60° depression and looks down at an object at the bottom of the hill. If the hill's height is 600 meters, the slope of the hill is... → **Problem (Relevance)**

<u>**Solution:**</u>

The expected answer to the paired problem is shown in Figure 3. As it can be seen, the worked example and the paired problem have similar procedures. Firstly, the problem is illustrated using a diagram; secondly, the angle measures are given; and thirdly, the side length needs to be computed using trigonometry, cosine that is the proportion of the altitude and the hypothenuse. The study worksheet presents several pairs to provide the acquisition of all trigonometry ratios (i.e. sine, cosine, tan). Therefore, it should at least contain three pairs of examples and problems.In this way, students might think analogically about the pattern of the problem solution: (1) illustrate the story into a figure with right angled triangle in it; (2) select the given measures; and (3) apply the relevant trigonometry ratio to find the unknown length. This might be critical to deepening their understanding since the abstraction and adaptation thinking processes when solving isomorphic mathematics word problems could facilitate a well zorganized knowledge acquisition.

Figure 3 The answer of the paired worked example



Discussion

The researchers created questions contextualized using agriculture-related themes, which can be used for high school students majoring in Agriculture when learning trigonometry as part of their compulsory mathematics course. This study uses ARCS as a strategy to maintain or increase student motivation. The researcher designed motivational sentences and question instructions at the beginning of the study worksheet to draw students' attention. Attention is considered an essential requirement for attaining greater motivation in class because it serves as an aspect to attract students' curiosity in learning something (Keller, 2010; Rebolledo-Méndez et al., 2010). Relevance entails informing learners about how the content relates to their needs. Sometimes students' statements appear stating, "I don't need to study this because it is not related to my future work". Students must believe that the instruction is related to important personal goals or motives and feel connected to the setting before they can be motivated to learn (Keller, 2010). Indeed, teachers should ensure that students believe the learning experience is personally relevant.

Self-confidence is the extent to which students believe that they can succeed. The motivational sentences at the beginning of the study worksheet are intended to increase student's self-confidence and attract student's attention. Confidence is also boosted by the presence of a solution with distinct stages in the worked example. The desire to feel competent is a basic human motivation, and how competent one feels in a given situation is reflected in one's feelings of self-confidence (Keller, 2010; White, 1959). The feeling of self-confidence is a very important factor for an individual to live a positive life, develop their own abilities, and use their positive aspects to be a successful individual (Toktas & Bas, 2019). Satisfaction is the extent to which students are satisfied with their learning outcomes.People like a certain amount of novelty, they like to feel competent, they like to build knowledge and skills in areas of personal interest and importance, and they like to experience a degree of control or autonomy. When all of these conditions are satisfied in a learning environment, intrinsic satisfaction results or is sustained due to successful achievement. Students lose interest when these conditions are unmet (Keller, 2010). The complete solution to the worked example is also intended to increase student satisfaction in this study. Students are satisfied with this comprehensive solution because they understand how to solve the problem (Keller, 2010; Turel & Ozer Sanal, 2018). Feelings of mastery and the pleasure of completing a meaningful and challenging task can lead to intrinsic satisfaction.

Motivational design is defined by Keller (2010) as the process of allocating resources and procedures to effect change in motivation. Malouff et al. (2008) state that there are various methods that teachers can use to increase student motivation, such as creating relevant material content and providing feedback on each student's skills. Another method that teachers can use to increase student motivation is to believe students can learn, which will increase student confidence and set goals that will make students pay attention to these goals (Wery & Thomson, 2013). Learning will occur when there is interaction between learning materials and the experiences of the students themselves (Lawson et al., 2005). Razon et al. (2012) found that group learning gives students a feeling of not being pressured because students have the opportunity to discuss with other students. However, learning worked examples in groups might not always be superior (Retnowati, Ayres, & Sweller, 2010, 2017).

A worked example is an instructional design in which students are given a step-by-step solution to a problem before being allowed to solve similar problems on their own (Ayres & Sweller, 2013). Worked examples have been suggested by cognitive load theorists as an effective strategy for reducing extraneous cognitive load and facilitating efficient schema acquisition compared with problem solving (Retnowati et al., 2010). Numerous studies indicate that this pairing methodology of study leads to better results for novices,particularly, when compared to a strategy that asks students to solve problems without first revealing worked examples (Ayres & Sweller, 2013). Worked examples can be useful for learning, but can also cause cognitive load. The amount of mental effort required to process information in working memory is referred to as cognitive load. When the cognitive load is too high, it can impede learning and result in errors or mental fatigue. One way that worked examples can cause extraneous cognitive load is by presenting redundant or too much similar information at once (redundancy effect) (Ayres & Sweller, 2005). If the steps in the example are too complex or there are too many steps, it can be overwhelming for students to process all the information. Additionally, if the example is presented too quickly, students may not have enough time to fully understand each step before moving on to the next. On the other hand, the split attention effect can be avoided by integrating explanatory text in complement and inside the picture. In this study, arrows are employed to point or integrate the text and picture.

Studying worked examples could be fostered by the procedure of the ARCS model. As described, the worked examples contain step-by-step solutions. Furthermore, students are given the opportunity to work on similar problems. Because the problems worked on paired problems have the same structure as those studied in worked examples (i.e. isomorphic), this learning design will assist students in making analogical thinking (Pastoriko & Retnowati, 2019). In order to solve the paired problem, students must rehearse the steps for solving the worked example they acquired. Students will use this as their prior knowledge, that is, drawing a triangle to illustrate the presented problems before determining the trigonometry ratio to find the length. In order to solve problems, students will apply their prior knowledge of angles measures, proportions and basic trigonometry.

The design of worked examples integrated with ARCS might be applied for novice students (Ayres & Sweller, 2013) since more knowledgeable students may experience redundancy when studying working examples, instead. Redundancy happens whenever numerous sources of information that can be understood separately are presented simultaneously (Chen et al., 2015). It is redundant to ask expert learners to study solutions to problems or steps in a solution that they are already familiar with because the presented solutions are at the same time already available in their minds. Extraneous cognitive load will occur by processing unnecessary information, interfering with learning the given problem (Ayres & Sweller, 2013). Learners are more actively engaged in creating new knowledge when they solve problems. Because of their high level of prior knowledge, it is hypothesized that worked examples might have no significant impact on more expert learners, although the ARCS method is explicitly instructed. Nevertheless, this study lacks empirical data to provide scientific evidence to explain this assumption.

Conclusion

Trigonometry is one of the mathematics topics typically learned in high school. Because of its high level of element of interactivity, trigonometry problem solving tends to be experienced as a complex learning process. Students should possess relevant mathematical concepts they learned in junior high schools, such as 'Pythagoras' Theorem, right angled triangles, and proportion. The design of worked examples in this study shows that it may reduce extraneous cognitive load, and the integrated ARCS method is expected to stimulate more learning motivation. This learning method will make it easier for students to obtain and process information. With the organized presentations of the solution steps in the worked example, the model can facilitate mathematics learning for novice students. Future research gathering empirical data on the effectiveness can provide a more convincing conclusion.

Summary and Implications

In a nutshell, the dance-based kinesthetic approach offers a fun and active way of learning that aims to improve students' scores, engagement, and retention of information.

By incorporating dance into the classroom, students can be more engaged and motivated in their learning, which may lead to a deeper understanding of the concepts. The structured nature of the dance helps students to remember the concepts and their order more effectively. Additionally, this approach is convenient for teachers as it requires minimal time to prepare and no material preparation. Overall, using dance as an instructional tool provides a beneficial and efficient teaching method that enhances student learning outcomes.

Limitations and Recommendations

Due to constraints faced in terms of time and other requirements needed to prepare students adequately for public examination, the first author only managed to pilot test her draft lesson plan developed through 5E instructional model using the Design and Development Research approach (Richey & Klein, 2014).

However, the preliminary findings of this study could serve as baseline data for the planning of bigger scale quasi-experimental study involving other samples with all prerequisites fulfilled, such as ensuring comparability of the samples using statistical analysis. The approach introduced in this study is effective in increasing students' engagement, improving their scores, and helping them retain the information longer. It is also efficient for busy teachers, as it requires minimal time to prepare and no material preparation. Based on the results of this study, it is recommended that schools and teachers may consider incorporating the kinesthetic approach into their teaching methods.

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