Analysis Report for Analysis Phase of ID Model

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**Topic of Instructional Design Project**

 My instructional design project will be developing instructional materials for AP Calculus AB high school students, as they review and prepare for the AP exam.

**Literature Review**

Advanced Placement Program (AP) such as Calculus AB (AP Calculus AB) is a college level course offered by the College Board to high school students. The course is equivalent to one semester of a college calculus course. The topics that are covered in AP Calculus AB are limits, derivatives, and integrals. Upon completion of the course, every year in the month of May students take a rigorous exam. It consists of 45 multiple choice questions and 6 free response questions (*AP Calculus AB and Calculus BC: Course and Exam Description*, 2016).

Based upon their raw score, students can receive a score between 1 and 5 (integer score) for their overall exam. The AP score is used to determine if students are recommended for college/university credit.

Table 1. AP Score and Recommendation



*Note:* From *AP Calculus AB and Calculus BC: Course and Exam Description*, p. 3, 2016, New York: College Board.

Table 1 shows the corresponding AP score and recommendation for college/university credit. Students who receive a score of 3 or better is given college credit for the course (*AP Calculus AB and Calculus BC: Course and Exam Description*). However, earning credit for the AP course varies among colleges and universities. Thus, students must check with the college or university of their interest regarding AP score and college credit.

 During the course one of the concept that many AP Calculus AB students struggle with is integrals. Integral is the third big topic in the course and is assessed in both the multiple choice and free response portion of the AP Calculus AB exam. In the free response portion, the topic is assessed in terms of applications. It requires students to utilize basic skills and conceptual understanding and apply it to situations. To help high school students understand the concept of integral, Kouropatov and Dreyfus (2013) created a curriculum that taught the integral concept as accumulation, where conceptual understanding of accumulation was derived from approximation. The curriculum was developed and piloted over a two-year period (2009-2011) for high school students who were in advanced level mathematics course before utilized in the research study. The experiment with the curriculum was with 12th graders, in five small groups, over a 10 session period that lasted 1.5 hours each. Based upon the Abstraction in Context framework, Kouropatov and Dreyfus (2013) and found that students who learned about the integral as proposed in the curriculum were able to construct the concept of integral “in a quite satisfactory and complete manner” (p. 650).

 In Kouropatov and Dreyfus’s (2013) research study, its curriculum and activities were designed in a manner that is worthwhile investigating and studying. The curriculum utilized activities that incorporated hands-on materials, such as “ruler, compass, protractor, scientific calculator, square paper” (Kouropatov & Dreyfus, 2013, p. 646) to construct the concept of approximation and accumulation, which led into constructing the integral concept. Kouropatov and Dreyfus’s (2013) research study suggested employing meaningful activities and organizing it a manner to develop students’ conceptual understanding of abstract mathematical concept. Activities should be built around an underlying concrete concept. The underlying concept is then utilized to derived and the abstract concept.

 Similarly, Dobbins, Gagnon, and Ulrich (2014), suggested teaching mathematic concepts to students who have difficulties in mathematics using graduated and peer-mediated instruction. Although Dobbins et al. (2014) suggestions were for Geometry students, the idea of the graduated instruction using the Concrete-Representational-Abstract (CRA) instructional approach was similar to that of Kouropatov and Dreyfus’s (2013) curriculum design. The idea of CRA, as presented by Dobbins et al. (2014) utilized manipulatives or hands-on materials at the Concrete phase (beginning of instruction), picture representation of the hands-on material at the Representational phase, and mathematical symbols or notation in the Abstract phase (last phase). Kouropatov and Dreyfus’s (2013) curriculum has this similar idea by using math accessories to assist students in constructing the concept of integral through approximating area and volume of geometric shapes (concrete phase), then approximating accumulating values of functions (representational phase), and eventually developing the integral concept and introducing its properties and application (abstract).

 Even though Dobbins et al. (2013), proposed the CRA technique to assist students with difficulties in mathematics, the steps in the instructional approach can be apply to any level mathematics course. Calculus, in particular, can benefit from this type of instructional approach because the concepts in the course is very abstract. Teachers can develop instructional materials for concepts like limits, derivative, and/or integral by focusing on the big idea or concept behind these abstract concepts. Therefore, when students are introduced to the mathematical vocabularies and notations, they can have a better understanding of how the abstract concept is constructed.

 In addition to the use of CRA, Dobbins et al. (2013) suggested the use of peer-mediated instruction. Peer Assisted Learning Strategies (PALS) was the peer-mediated instruction Dobbins et al. (2013) proposed to utilize in helping students who have difficulty with mathematics. PALS is a structured approach that gives students opportunity to work in pairs (a higher performing student paired with a lower performing student). Students are engaged in taking turns coaching and practicing content materials. PALS provides structure time for students to practice fluency in mathematics (math skills and procedures). Although students may be enrolled in an advanced mathematics course, there is an array of students’ math proficiency level. Peer-mediated instruction, such as PALS, can definitely be employ to help reinforce what is taught, give students opportunity to practice and get instant feedback about their work.

 Providing students time to practice and get feedback about their understanding of content material is important in a math classroom. Furthermore, teachers can also assist students in learning mathematics by understanding how cognitive load plays a rule in processing mathematical information. Chinnappan and Chandler (2010), discussed about the cognitive process and how cognitive load impacts working and long-term memory. They described how high cognitive load (such as intrinsic and extraneous) can reduce mental resources to develop schemas. Chinnappan and Chandler (2010) suggested mathematics teachers to be aware of high intrinsic and extraneous load task. The intrinsic load is created by how complex a task is and if a task is very complex, teachers should take the task and break it down into smaller chunk. The extraneous load is created by the format for instruction. Teachers should be aware of how text and visual can create high extraneous load task when they are not properly organized. Chinnappan and Chandler (2010) recommended minimizing high extraneous load tasks, especially if they are not related to learning. They also proposed to utilized an integrated approach of steps and visual for geometry to reduce split-attention. Teachers are encouraged to increased task that requires germane load, where students have to construct their response by making connections to their prior knowledge (Chinnappan & Chandler, 2010). Germane load task supports schema development in long term memory. Chinnappan and Chandler (2010) suggested worked example supports schema development in mathematics. Worked example of a problem is a low intrinsic and extraneous load task because the all the step to the solution is already provided (Chinnappan & Chandler, 2010). Teachers can utilize worked example of a problem at the beginning of practicing procedural fluency of concept. Students can use their working memory to understand the problem and solution, which promotes germane load tasks. However, Chinnappan and Chandler (2010) also stated that worked example would only be beneficial to students will low prior knowledge of the math concept. Students who have tremendous amount expertise of the concept would benefit more from solving a problem verses working with worked example.

Similarly, Ayres’s (2006) research on minimizing intrinsic cognitive load in mathematics supports what Chinnappan and Chandler (2010) had proposed. Ayres (2006) lowered cognitive load task by minimizing complexity of problems. In the research study, there were three groups, isolated (making a single calculation), integrated (making whole calculations), and mixed (mix approach of isolated and integrated), who were involved in working out multi-step algebraic tasks (Ayres, 2006). The findings from the study showed that single calculation or part tasks reduced intrinsic cognitive load. Furthermore, single calculation task was more beneficial to students who were of lower ability while whole calculation tasks were more beneficial to students with higher ability (Ayres, 2006).

When teaching AP Calculus AB or any mathematics course, teachers should be conscious

about their student’s mathematics ability and the effect of cognitive load. With both of these in

mind, teachers can develop appropriate instructional materials to meet the needs of their students by reducing high intrinsic and extraneous load tasks. Teachers can develop instructional materials that foster schema development in mathematics. This can be done by sequencing the presentation of materials using a graduated instructional approach, which promotes conceptual understand of abstract mathematical concept. Furthermore, teachers can structure peer mediated instruction into practice to provide support, immediate feedback, and interaction between students.

**Analysis**

Need Analysis

The AP Calculus AB exam is approaching rapidly. The course content materials were already taught to the students. The students are in review mode in preparation for the exam and need to review the big ideas/topic in the course. As revealed from students’ score from the practice mock exam, integral was the topic students were the weakest, in comparison to limits and derivative. Furthermore, based on classroom observations of students, while working on review multiple choice and free response questions from previous released exam, students need more assistant with integral concept and how it is being assess on the exam.

Learner Analysis

The learners for my project are AP Calculus AB high school students. They are 11th and 12 graders. They have already been taught all three topics in the course (limits, derivatives, and integrals). It is reasonable to expect that the students can learn what needs to be learned because the content had already been taught and the students are in need of a review. Specifically relating to integral, students know how to:

* Find basic antiderivatives
* Approximate area under the curve using Riemann Sum
* Use Fundamental Theorem of Calculus to evaluate definite integrals
* Write functions defined by an integral
* Interpret the meaning of a definite integral within a problem
* Apply definite integral to solve problems involving average value of a function
* Apply definite integrals to problems involving motion
* Apply definite integrals to problems involving area and volume
* Solve separable differential equations

Entry behaviors for AP Calculus AB high school students are using a TI-89 titanium graphing calculator and internet. Graphing calculator skills is necessary for the review because the exam has calculator and non-calculator portion (for both multiple choice and free response) These students have a positive attitude toward the content because many of the students plan to attend college and are motivated to try and earn college credit.

The students all have a positive attitude toward classroom setting delivery system because this was what every student had indicated, on the survey, as how they would like the content to be retaught. Based on classroom observations, the students preferred to take notes during a lesson, especially when a new topic is introduced. In terms of review, students indicated in the follow-up focus group interview that they preferred to have the instructor to teach or review the concept. They also indicated wanting examples for practice. In terms of learning task, they suggested to first have time to work individually and then merge into pairs or group on the same task because they would like some time to think and try out the task prior to collaborating with others. In addition to the classroom delivery system, a couple of students indicated on the survey an interest in videos and self-instruction as a delivery system. In the follow up focus group interview, the students expressed an interest in having only short videos for reviewing concept and procedural skills.

Instructional Analysis

Based upon the electronic survey, specific topic relating to integral the majority of the students indicated a preference of a re-teaching on how to apply definite integrals to problems involving motion. In the survey, student also expressed an interest to review of the concept and practice. The follow up focus group interview showed that the students would like to practice procedural skills related to the concept. They also would prefer to practice problems similar to that of AP Calculus AB problems, from the College Board.

The goal for this project is AP Calculus AB high school students will have a better understanding of integral concepts for the AP exam, by participating in re-teaching of concept and procedures on applying definite integrals to problems involving motion in a classroom setting.

**Flow Chart of Goals and Sub-Goals**

**Goal:** AP Calculus AB high school students will have a better understanding of integral concepts for the AP exam, by participating in re-teaching of concept and procedures on applying definite integrals to problems involving motion in a classroom setting.

**Sub-Goal 1:** AP Calculus AB high school students will calculate the displacement of a particle in rectilinear motion over an interval of time, using the definite integral of velocity.

**Sub-Goal 2:** AP Calculus AB high school students will calculate the total distance of a particle in rectilinear motion over an interval of time, using the definite integral of speed.

**Sub-Goal 3:** AP Calculus AB high school students will determine the position of a particle in rectilinear motion over an interval of time using, using the Fundamental Theorem of Calculus.

**References**

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