DESIGNING FOR MEANINGFUL LEARNING: USING ADDIE MODEL TO INTEGRATE VISUALISATION INTO DATA ANALYTIC

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ABSTRACT

This paper proposes ADDIE Model Design Plan in the development of visualisation learning module for undergraduate students in Malaysia. Visualisation learning module for data analytics courses (ADaVis) aims to assist students in building stronger conceptual understanding so that they may benefit the learned concepts by real life application. Visualisation exploits suitable visual elements to encourage learning by presenting authentic learning materials in interactive ways. Meaningful learning attempts to associate new concepts with existing cognitive structures through conceptualization and construction of systematic links. The development of the learning module applies ADDIE Model as an instructional methodology. The five steps in ADDIE model namely analysis, design, development, implementation and evaluation are elaborated to highlight the detail procedures in generating the learning module. Evaluation step in ADDIE Model is enhanced to include iterative approach to allow recursive process to fulfil user requirement and to ensure the effectiveness of the selected visual contents and embedded meaningful learning elements. ADDIE Model Design Plan of visualisation learning module development emphasizes visualisation strategy based on three design theories to create meaningful learning experiences. The instructional design plan is expected to guide and assist developers to deliver learning products by following optimal instructional design methods and guidelines. The system-oriented instructional system design approach demonstrates extensive procedure to create instructional experiences by gaining an overview of the learning process in an effective and efficient way to produce meaningful learning using visualization technique.

Keywords: ADDIE model, learning module, data analytics, visualisation, meaningful learning

1. INTRODUCTION

ADDIE model is a generic and comprehensive model of instructional system design that includes a set of criteria and continuous reviews to complete the instructional product development and testing (Donmez & Cagiltay, 2016). Five core components of ADDIE model, namely analysis, design, development, implementation, and evaluation consist of a set of sub-

activities that fit the context of learning module construction (Muslimin, Nordin, & Mansor, 2017; Zulkifli, Razak, & Mahmood, 2018). Following module development, experimental design is conducted to ensure effectiveness of learning module on the intended functions (Boettger & Lam, 2013).

Learning module consists of a collection of designed materials to deliver learning content and to support identified learning goals (Taguchi & Matsushita, 2018). In higher education context, students as key users of learning module may benefit from this collection of materials that promote self-directed learning while course instructors can diversify their learning methods by reference to the module (Rittle-Johnson & Loehr, 2017; Siregar, Rosli, & Maat, 2019). In this study, the learning module namely *Analitik Data Visual* Module (AdaVis Module) is intended for data analytics courses offered at the tertiary level in order to develop data-driven capabilities.

Data analytics courses include learning content that focuses on the mastery of statistics which emphasizes the ability to use and relate statistical concepts as well as draw conclusions with statistical ideas and conduct data-based justifications (Zieffler, Garfield, & Fry, 2018). Due to the rapid growth of data sources and the desire to leverage data to support decisions in daily life, data analytics courses are gaining ground in institutions of higher learning (Connelly, 2018).

The learning module highlights visualization as the selected learning technique to present learning concepts, assisted by a well-designed interactive visual interface to encourage learning using all appropriate visual elements (Avella, Kebritchi, Nunn, & Kanai, 2016). Visualization is listed as one of the emerging technologies that is dominant in higher education in line with game-based learning and analytical learning (Ngambi, 2013). Visualization techniques used in this study include simulation, advance organiser and concept map detailing learning concepts through illustrations and graphics to enrich the explanation of the concepts relevancy to existing constructs and the relationship between concepts.

Meaningful learning emphasises the relevancy of concepts being learned to previous experiences and knowledge through refinement of concepts and construction of new links (Vallori, 2014). Meaningful learning consists of five important elements: active, authentic, constructive, cooperative and goal-based (Fan, Xiao, & Su, 2015). In the context of higher education, meaningful learning facilitates the application of learned concepts to the real world and to prepare students with a broad range of skills (Guimarães, César, Machado, & Fernandes, 2018; Hairulliza, Roslinda, & Capraro, 2018; Ismail & Groccia, 2018; Priniski et al., 2018).

Utilisation of learning module in course implementation is encouraged to support the development of understanding, communication, cooperation and reflection of knowledge (Karki et al., 2018). The development of the learning module applies ADDIE Model as an instructional methodology. Some of the elements in ADDIE Model are enhanced to include iterative approach to allow recursive process to fulfil user requirement and to embed the selected visual contents. This paper proposes ADDIE Model Design Plan in the development of visualisation learning module application for undergraduate students in Malaysia. The design plan is elaborated to specify requirements and components in each process.

2. ADDIE MODEL

There are many instructional system design models to be used in module development studies. Each model carries its own strategy for achieving the intended goals. In addition to ADDIE model, other models such as Morrison, Ross and Kemp, Seels and Glasgow models, and the Dick and Carey models are based on instructional system design.

ADDIE model is a structure to develop learning module as it provides a supportive framework in the design process as recommended (Hai-Jew, 2019; Laurillard, 2013). ADDIE model is capable of assisting educators in institutions of higher learning as learning products developers by following optimal instructional design methods and guidelines (Laurillard, Kennedy, Charlton, & Wild, 2018). Instructional products are used to enhance students' knowledge and skills.

Compared to the early stages of its emergence, ADDIE model like other instructional system design models have also been refined and improved (Hai-Jew, 2019), to tend to be more flexible, comprehensive and iterative (Oh & Reeves, 2010). ADDIE model is also one of the most widely used instructional system design models by researchers (Durak & Ataizi, 2016) due to its practical approach (Alodwan & Almosa, 2018) and to its relevancy to research cycle (Tobase et al., 2017).

Among important contributions of ADDIE model in the development of instructional products include the formalization of analysis and design that help reinforce the developmental information, followed by implementation and subsequently the importance of evaluating the effectiveness of learning resources (Hai-Jew, 2019). The details of the activities that fall under each of the core components of system-oriented model, ADDIE help researchers develop appropriate strategies in developing their instructional products (Muslimin et al., 2017).

In this study, ADaVis module is intended to help students relate learning concepts to tailor to their learning contexts in order to build strong and systematic knowledge structures. To assist its development, ADDIE model provides a unique set of principles and procedures so that the overall learning module can be developed in a consistent and reliable manner (Banerjee, 2016; Hess & Greer, 2016).

3. INSTRUCTIONAL DESIGN PLAN

The entire study is conducted using ADaVis Module Construction and Effectiveness Methodology consisting of two phases. The first phase involves the construction of the ADaVis module using ADDIE model-based instructional design approach. The second phase involves testing the effectiveness of the ADaVis Module using experimental design. The methodology used in the entire study coincides with a similar study on the development and effectiveness of learning module which separates the research into two phases (Mohd Jasmy et al. 2014). This paper solely focuses on the first phase of the whole methodology. Figure 1 presents the methodology in phase 1 using ADDIE model.

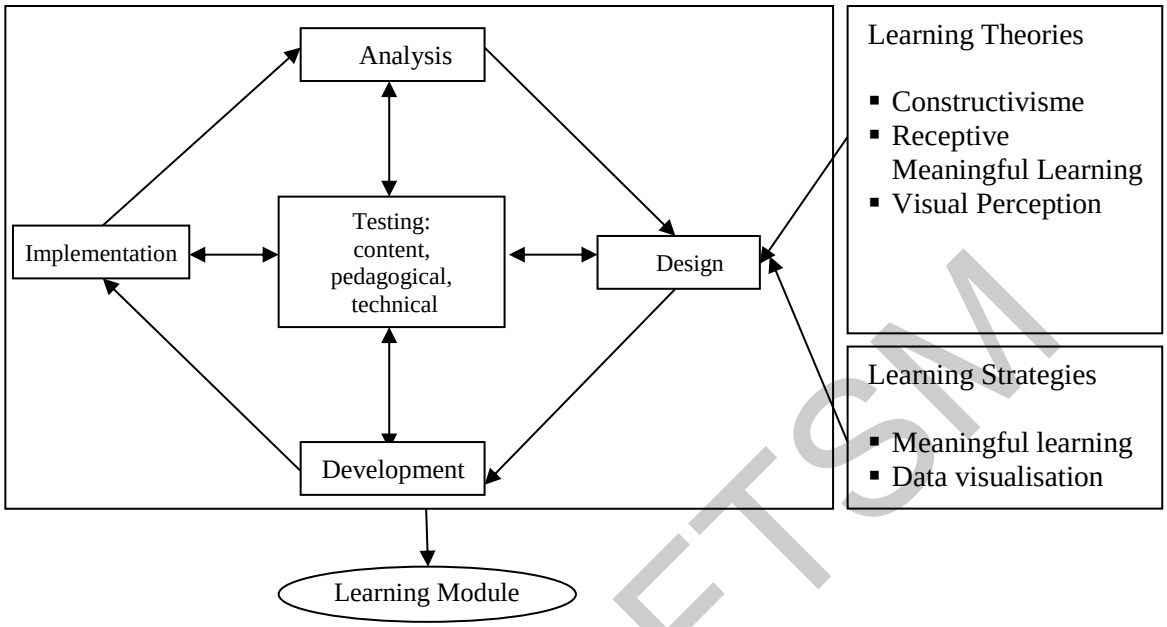


Figure 1: Development of ADaVis Module using ADDIE Mode

ADDIE Model Steps and Procedure

Five steps in ADDIE model are described in this section together with the detail procedure.

Step 1: Analysis

Analysis is the first step of ADDIE Model and is considered critical for conducting analysis through literature review, preliminary research, observation and experience to determine the direction of the study based on the encountered issues and gaps. The purpose of this step is to identify the causes of learning problems and recommend solutions through appropriate approaches (Huang, Spector, & Yang, 2019). The focus of this step is to identify data analytical learning problems and to identify the appropriate framework for the two selected strategies namely meaningful learning and visualisation.

(1) Learning problems analysis.

The instructional designer proposes the learning module to existing courses of analytic data implemented in higher education level. Thus, the initial procedure is to validate the problems in analytic data learning using extensive literature review and identify the causes of the learning problem. The identified problems concern with lack of opportunities for students to study in depth to get connections between concepts they learn (Bisson, Gilmore, Inglis, & Jones, 2016).

(2) Students and context profile.

The procedure is to identify the abilities, experiences, preferences, and motivation of students. Compilation of students profile also include student academic background, attitudes, skills, and experience.

(3) Learning strategy analysis.

The aim of this procedure is to generate goals that respond to learning problems that are caused by a lack of knowledge and skill. In this research, the instructional goal is students be able to see clearly the link between concepts and be able to apply the concepts in real life situation. Next, the procedure is to evaluate various instructional techniques and delivery systems. This procedure is important to recommend the best option to address the crucial learning problems. From the extensive literature review, the designer proposes visualisation technique in meaningful learning environment as the solution and intervention to overcome the identified problems related to lack of conceptual understanding. The designer considers the principles of Constructivisme Learning Theory besides Meaningful Reception Learning Theory and Visual Perception Theory (presented in Figure 2). These theories aim to guide and propose efficient instruction for successful learning outcomes (Khalil & Elkhider, 2019).

Step 2: Design

The second step involves design activities to create the desired performances and to embed important features in the learning module. The step facilitates instructors to prepare a set of functional specifications to address the learning problems related to lack of conceptual understanding. This step also helps to identify meaningful learning and visualization elements

that contribute positively to data analytical learning problems (Moradmand, Datta, & Oakley, 2014). These activities involve designing visual attributes, designing visual frameworks and designing ADaVis learning module materials and teaching and learning strategies. The basics of this module design are based on Constructivism Theory, Meaningful Learning Learning Theory and Visual Perception Theory. The andragogic assumptions of adult education in the selected theories are due to students profile (Tobase et al., 2017).

(1) Create a task list.

This procedure is to identify the essential tasks required to achieve an instructional goal. The task list main role is to regulate the module content to help students construct the knowledge and skills necessary to achieve the instructional goals. Among the procedure in task analysis is to recall the problem statement and justify the ADaVis module instructional goals. The designer establishes three important performance tasks, active learning, constructive learning and authentic learning; and identifies two essential knowledge and skills i.e. statistical skills and statistics conceptual understanding.

(2) Compose learning objectives.

This procedure aims to develop learning objectives that are coherent with the instructional goals. One of the learning performance is related to statistical skills. Therefore, this performance objective suggests a method to evaluate students based on a specific desired performance. The learning objectives emphasizes the use of measurable verbs that intend to help students to move from the beginning level to the intermediate and advance levels. Once the designer identify the learning objectives, the next procedure is to select the appropriate learning materials and to identify learning assessments (Khalil & Elkhider, 2019).

(3) Create learning materials

This procedure aims to generate learning materials based on the learning objectives identified in the previous procedure. Therefore, the main activity in this procedure focuses on creating subject content that particularly address the cognitive level of the learning objectives (Khalil & Elkhider, 2019). This is accompanied by designing learning activities to ensure that

students be able to engage with the learning materials. To specify the interaction in the learning process, the designer clarifies instructors' and students' contribution during the instructional period.

(4) Generate testing strategies.

This procedure aims to develop instruments to evaluate students' performance. The main focus in this procedure is to identify learning assessments to monitor students progress (Khalil & Elkhider, 2019). The evaluation procedure should consider authentic learning element to simulate real performance to reflect the task and performance objective in the module.

Step 3: Development

In the third step of ADDIE instructional design process, development activities are conducted to generate ADaVis module. This phase require the instructor to recognise relevant resources and development tools for developing the module. The development step aims to produce instructional products with a description of the selected learning strategies and visual elements in the planned module (Tobase et al., 2017). In this step, learning objectives are identified, visual attributes are developed, visual frameworks are developed and the contents of the module are detailed. Subsequently the ADaVis learning module are developed. Some of the screenshots are presented in Figure 3 and 4.

(1) Create content and component.

The aim of this procedure is to create instructional plans. Learning content plays an important role in creating an interesting materials to engage students. During the knowledge construction process, students access the content to evaluate and relate to the prior knowledge and concepts available in the memory. Therefore, learning instructions should considers strategies to introduce learning content efficiently in the materials.

(2) Apply various media.

The aim of this procedure is to use media efficiently to promote the performance objectives. Effective use of various media enhances the construction and retention of knowledge and skills. These instructional media have a variety of elements to facilitate the performance objectives to boost students' learning experience. For the efficient use of media, the principles of multimedia design and cognitive load theory guidelines could be applied to create the instructional materials (Khalil & Elkhider, 2019).

(3) Develop guidance for students and instructor.

The aim of this procedure is to provide information to guide the student and instructor through the instruction. The provided guidance for navigating the instructional strategies enhances the learning experience.

(4) Conduct formative revisions.

The aim of this procedure is to review ADaVis module before implementation. Among the suitable tests include evaluation to improve the designed instruction so that it can fulfill its goal to enhance conceptual understanding.

Step 4: Implementation

In the fourth step of ADDIE model, implementation stage is conducted to arrange for the real learning environments. The implementation strategy allows students to experience the learning module by constructing the intended skills. The implementation provides a chance and circumstance to conduct the initial plan in the design phase and to make sure the details perform as expected (Khalil & Elkhider, 2019).

In the implementation step, the prototype for the ADaVis learning module is used in the teaching and learning context for a group of 10 students as a pilot study. Implementation steps aim at preparing for the real learning environment and planning for student engagement (Huang et al., 2019). This assessment is important to identify any problems in the module being developed. The feedback obtained is used to improve the module. The selection of 10 people

in the pilot is appropriate due to similar characteristics to the actual study (Somekh & Lewin, 2005).

(1) Prepare instructor and learning environment.

The aim of this activity is to recognize the role of instructor in the learning process and to sufficiently inform the instructional strategies and the learning module. Besides, the lecture or tutorial rooms require certain layout, equipment, and technology that warrant for early preparation (Khalil & Elkhider, 2019). For example, the authentic learning environment requires the use of contextual learning materials that students may find familiarity and fit easily to their real life. Therefore, it is important to arrange the learning setting that is conducive for the implementation of ADaVis module.

(2) Prepare the student.

To implement the module, students need to be prepared with sufficient information to help them to actively engage in the instruction and effectively interact with ADaVis module. Students should have enough exposure on the instructional context and technology and proper essential orientation on the applied hardware and software of the module (Khalil & Elkhider, 2019).

(3) Implement the learning module

To conduct the new launch materials into a real learning environment, there are various coordination to execute the preparation. Enough guidance and information are required to provide support to instructor and students. The use of assessment instruments aim to identify errors and problems.

Step 5: Evaluation

In the fifth step of ADDIE instructional design process, evaluation is conducted to assess the materials in ADaVis module. Furthermore, the step aims also to evaluate the instructional design procedures used to develop ADaVis module. The evaluation of instructional design

emphasises on assessing students response on the module in constructing statistics skills in a real learning environment.

Evaluation aims to measure the quality of output related to AdaVis learning module in three aspects: content, pedagogical and technical. Therefore, it involves assessment before and after module implementation to evaluate the instructional design procedures used to generate the module (Huang et al., 2019).

Among the evaluation involves a usability test on ADaVis Module. Ten students in the pilot study using the ADaVis module were involved in this assessment. The usability instrument assesses issues related to design, navigation, and other aspects. For investigation and in relation to meeting general quality criteria from empirical research, usability testing instruments are used. The purpose of assessment is to meet general quality criteria through empirical studies using usability testing instruments (Pirnay-Dummer, Ifenthaler, & Spector, 2010).

Likewise, a summary assessment module is carried out by a field specialist to confirm that the module meets the specifications. The study involved six field specialists, each of whom was three in the field of data analytics and instructional system design. All of this feedback was recorded and analyzed for improvement purposes. The number of specialists used is determined by the appropriateness of the assessment task (Brown & Green, 2016). For the purpose of validating the content of ADaVis Module, three individuals representing each of the experts in the field of data analytics and instructional design are considered sufficient and appropriate.

(1) Determine evaluation criteria.

The aim of this procedure is to identify perception, learning, and performance as the three main levels of evaluation associated with ADaVis module. Three levels of evaluation is planned with their respective objectives (Huang et al., 2019). Level 1 evaluation assesses students' perceptions of the module content, resources used throughout the module, and the ease of module navigation. Level 2 evaluation assesses students ability to perform the tasks indicated

in each of the goals and objectives. Level 3 evaluation assesses learning performance that students gain statistics skill in the learning process.

(2) Select evaluation tools.

This activity aims to identify appropriate measurement tools suitable to instructional designers (Huang et al., 2019).The choice is not limited to quiz, reflection items, usability questionnaire, interview protocol, Likert scale, open-ended questions, survey, examinations, role-plays, observations, practice, simulations, authentic work tasks, performance checklists, peer reviews, and observations but may combine some of the options.

(3) Conduct evaluations

The intended evaluation is conducted to receive response from students regarding their experience using the module. Students response on the clarity, accuracy, sequence and difficulty level in the usability evaluation will be used to guide improvement in module development (Khalil & Elkhider, 2019).

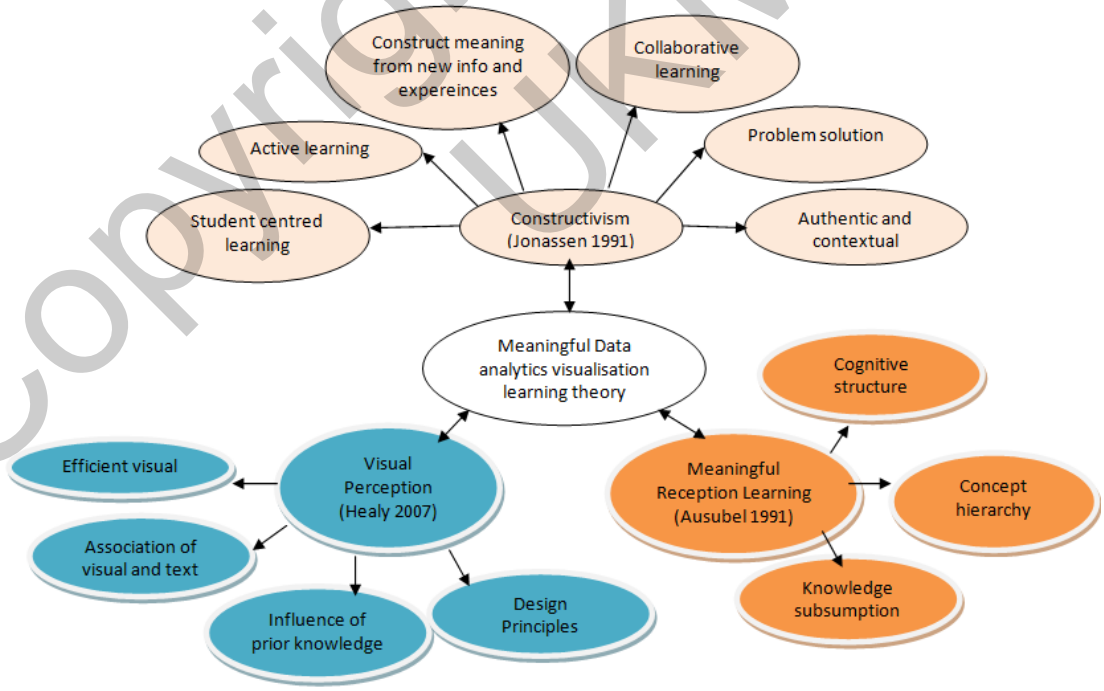
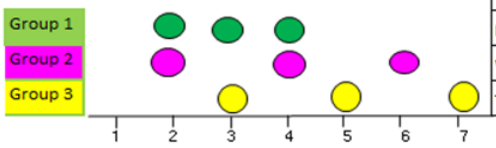


Figure 2: Learning Theories of ADaVis Module from Extensive Review of Literature

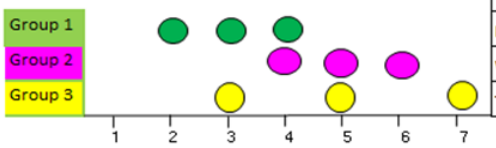
Analysis of Variance Explained Visually.

Identify a dataset consists of three groups in only one dimensions, like score, weight. This dataset can be plotted side by side to view the variance exist. But if we want to measure the variation, ANOVA finds the value of variation in three sources: between sample, within sample and total. The respective sum of square and mean square values provide the F test statistic. The larger F value contributes to higher chance for the groups to show significant difference in population mean value. ANOVA is about measuring the difference based o variance.

Notice the changes of data points in the following visualization to see how the variation from three sources responds.



Variation	Sum of square	df	Mean square	F	p-value
Between sample	6	2	3	1	0.422
Within Sample	18	6	3		
Total	24	8			



Variation	Sum of square	s of fr	Mean square	F	p-value
Between sample	8	2	4	2	0.216
Within Sample	12	6	2		
Total	20	8			

Figure 3: Screenshot of concept elaboration in ADaVis Module

Activity 2

Collaborate with your peers. Use concept map and construct relationship between various topics:

a) Refer to anova concept map. Reflect on various concepts available in anova.

b) Using concept map, Identify the differences in anova and :

I. Independent sample t- test
II. Paired sample t-test
III. Goodness of fit test
IV. Independent test

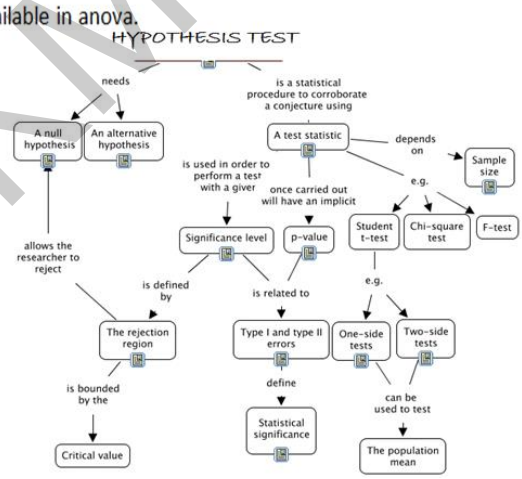


Figure 4: Screenshot of collaborative activity in ADaVis Module

4. DISCUSSION AND CONCLUSIONS

This paper proposes ADDIE Model Design Plan in the development of visualisation learning module application for undergraduate students in Malaysia. The design plan is elaborated to specify requirements and components in each process. Evaluation step in ADDIE Model is enhanced to include iterative approach to allow recursive process to fulfil user requirement and to ensure the effectiveness of the selected visual contents and embedded meaningful learning elements (Muslimin et al., 2017). The refined version allows the development process to be more flexible, comprehensive and iterative (Hai-Jew, 2019).

Enhancement model demonstrates that evaluation step to be in the centre to facilitate interaction with all other steps, as presented in Figure 1, in an integration development cycle (Tobase et al., 2017). In other instructional product development related to gamification, an added element of Scrum in AGILE model is proposed to complement ADDIE model (Nur Rahmah, Rosadah, & Yuzita, 2017)due to stronger combination and special attention to game elements evaluation (Kapp 2014).

The development process generates ADaVis learning module that aims to assist students in enhancing their conceptual understanding. The design considers students profile as guided in Constructivism Learning Theory to promote self-directed learning and be able to control their own study progress (Rittle-Johnson & Loehr, 2017). Besides, students are more capable of relating concepts in the cognitive structure if they construct their own understanding rather than accepting passively the information (Jonassen, 1995).

The learning content covers important topic in data analytics namely ANOVA. The design emphasise on boosting statistics conceptual understanding by using visual presentation (Hairulliza, Iksan, & Ashaari, 2019). The current intervention and education policy on data analytics are moving towards improving conceptual understanding (Hybsova & Leppink, 2015; Tobías-lara & Gómez-blancarte, 2019). Strong conceptual understanding allows students to produce critical thinking, response more flexible and make better decision making (Crooks, Bartel, & Alibali, 2019; Heijltjes, van Gog, Leppink, & Paas, 2014).

The learning module applies visualisation strategy to utilize the power of imagination and illustration to present the learning constructs for better understanding and absorption (Mardiana & Marlia, 2020; Nurizwan, 2014). The design has considered visual elements such as advance organiser to be used optimally in data analytics learning to enhance understanding, as proposed in Visual perception theory (Kubovy, Epstein, & Gepshtein, 2013). The visual design also exploits graphics and illustrations to enhance interactive capability for learning exploration based on various cases of data distribution (Klerkx, Verbert, & Duval, 2014).

The design considers learning material that encourages students to relate the new concepts to their previous knowledge and experience. The strategy persuades students to be committed in constructing knowledge in self directed learning, as promoted in Meaningful Learning (Ausubel, 2000). The design also highlights visual elements as attraction to engage in learning process as part of authentic and active learning activities in developing problem solving skills (Dierker et al., 2016; Karki et al., 2018).

As a conclusion, the paper has elaborated ADDIE Model Design Plan in the development of visualisation learning module application for data analytics course. The instructional design approach emphasizes a systematic strategy based on Constructivism Therory, Meaningful Learning Theory and Visual Perception Theory to develop instructional products that create learning experiences to support the development and acquisition of knowledge and skills. The system-oriented instructional system design approach aims to create instructional experiences by gaining an overview of the learning process in an effective and efficient way to produce good learning results. The scheme is expected to guide and assist developers to deliver learning products by following optimal instructional design methods and guidelines.

5. ACKNOWLEDGEMENT

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