

Cognitive Visual Support Design for Efficient Data Analytics Learning Based on Meaningful Reception Learning Theory

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Abstract: Among the main issues in data analytics learning relate to in-depth understanding and concept integration. Meaningful reception learning theory demonstrates cognitive visual tools to organize knowledge by linking new information with existing concepts in strong cognitive structure. This study describes essential characteristic in data analytics and request a cognitive visual model to appreciate literature performance. The study applies meaningful reception learning theory by contributing users with three character of instructional arrangement as visual cognitive support to build strong understanding structure i.e. active, collaborative and constructive. The model is expected to help instructors in systematically constructing data analytics component for efficient learning.

Keywords: cognitive visual tools, data analytics, collaborative, constructive

I. INTRODUCTION

Data analytics is a process of examining, presenting and explaining data in a way that is easy to understand and useful to users. Data analytics plays an important role in conveying description and meaning to numbers and figures to be used by decision makers in the relevant field, or otherwise data are wasted and useless. Teaching and learning of data analytics in higher education institutions receive numerous attentions and efforts to improve the quality of teaching and student learning especially to enhance students' engagement and to promote their understanding of particular concepts. Various negative perceptions relating to the courses as difficult, and unpleasant [1], [2].

Many students report their difficulties to comprehend and utilize statistical concepts and procedures [3]. Students rarely have the opportunity to develop in-depth understanding of what they have learned and soon they forget about the concepts after completing the course [4]. These difficulties cause students to tend to memorize the procedures without really understanding the process. Failure to develop an in-depth understanding of concept integration affects the clarity of learning and retention of student knowledge. This is also one of the reasons why students remain in the novice level in statistical thinking even though they have been exposed to various statistical bases [5].

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Data analytic pedagogy emphasizes the ability to evaluate and think statistically in data analytic curriculum [6]. This includes the importance of preparing students in ways and techniques to apply statistical analysis in a variety of different contexts, familiarizing them to think and making statistical reasons in various situations, as well as raising awareness and acceptance of these technological developments. A meaningful learning approach is thought to be accurate and appropriate for its effectiveness in helping students build a more in-depth understanding of statistics and preparation for application in the real world.

The emergence of data visualization as one of the new technologies has been a dominant element in higher education in line with game-based learning and analytic learning [7]. Data visualization or visual data analysis can potentially enhance optimum learning interactions including how and when students and teachers interconnect and engage with their knowledge, peers and environment [8]. Visual tools may produces meaningful learning [7], but its achievement and effectiveness do not come automatically but require a planned learning strategy [9], [10].

The problems posed by the current scenario in data analytics information display the need for cognitive visual support to assist instructors in expanding improved problem-based learning materials in their assignments and for arranging a instructional assistance for students constructing their knowledge and problem-solving skills. Thus, this study proposes specific framework as a collection of all needed ideas, concepts, examples, scenarios, as a designed and constructed material to contribute the support required by these students in data analytics learning. Therefore, this study analyze essential characteristic in data analytics and request a cognitive visual model to appreciate research performance.

The scope of the study is set to cover data analytics courses offered at higher education levels that demonstrate the technical characteristics, complexity and current patterns of meaningful literacy and understanding of data. This study limits data analytics to widely used techniques of statistical analysis and learning outcomes focusing on statistical skills over those skills related to data mining and machine learning.

II. MEANINGFUL RECEPTION THEORY IN DATA ANALYTICS LEARNING

Meaningful Reception Learning Theory was developed by Ausubel who suggested that students be supported with relevant facts to better understand the lesson. For example, advance organizers are practiced as a strategy to integrate main ideas before lessons begin [11]. The organizer give a comprehensive overview of concepts to enhance students' engagement and curiosity [12].

Similarly, the presentation of ideas using concept map enables students to relate the connection between concepts and to explain complex concepts [13]. Concept map does not only facilitate meaningful learning (ML). It builds knowledge through a strong framework by connecting the new context with the old ones, and enhancing knowledge retention for long term. Concept map is able to highlight key ideas that enhance brain stimulation to process and advocate knowledge in hierarchical order, thereby enhancing learning achievement [14], [15].

Scaffolding such as concept maps stimulates new knowledge and understanding based on existing knowledge by linking existing knowledge to newly learned concepts using information integration [16]–[18]. Learning is meaningful when students understand what they are learning and begin to use their knowledge in daily practice [19]. Hence, students are able to gain many learning benefits through practice and activities. To create a learning environment with such an element, educators should be able to understand students with the purpose and content of learning including encouraging students to participate actively.

According to [11], meaningful learning is the process of linking new information with existing concepts in cognitive structure. In meaningful learning, prior knowledge was considered the most important in teaching and learning process [21]. In this way, new information is combined with existing ones to update cognitive structure, significance and attribution. Students do not memorize, but learn logically and meaningfully through planned activities that manipulate intellectual development [22].

This study identifies the components in meaningful learning by referring to the meaningful learning model developed by [23]. This model was refined among others, are by [24]. The model suggests that meaningful learning elements can be divided into five items that are active, constructive, cooperative, authentic, and purposeful. This meaningful learning feature should be embedded in the learning model as a learning process.

Active learning can be defined as cognitive activities that involve students in doing something and thinking about what they do to make it clear and be able to adapt to new knowledge [25]. This is because learning is based on the

process of appreciation of the new concept. Students have the ability to learn and adapt to the environment through experimentation and manipulation of the environment using existing tools and information. Constructive element is closely linked to Constructive Learning Theory, suggests that individuals build their own understanding and knowledge through their own experience [26]. Hence, students are responsible for finding their own knowledge and learning new things that can be utilized in expanding the potential [27].

Collaborative learning refers to the environment in which a group of students engage in learning tasks and requires each individual to contribute to the group and be responsible for each other [28]. Therefore, cooperation to find understanding, meaning or an important solution is needed to create an effective learning environment. Peer networks built into collaborative groups allow students to support each other socially and academically including helping students in dealing with common difficulties such as stress and isolation [29]. This network serves as a solid foundation for effective peer-to-peer learning because of strong impetus and accumulated energy to solve learning problems effectively where students are comfortable and willing to share their knowledge and experience, exchange ideas, and help each other [30].

Authentic learning refers to real-world learning. Authentic educational techniques emphasize the relevance of taught concepts with actual scenarios regarding problems and applications [31], [32]. Authentic learning can encourage students' interest because these learning materials are relevant to their lives and environment [33]. Students also become more prepared in the future as learning materials reflect the real life context and can equip themselves with practical and useful skills [34].

Purposeful learning comes from student's intention in fulfilling educational goals. Learning becomes most meaningful when it is intentional and has a clear goal [35]. Students follow the learning process to meet certain goals especially to achieve cognitive and affective maturity. If students are actively learning and deliberately trying to achieve cognitive goals, they think and learn effectively as they work to fulfill their intentions and desires.

Due to its convenient relevancy to data analytics research, three approaches, i.e. active, collaborative and constructive elements will be completed in the study. Despite their functional operation in data analytics learning, these access have not yet considered in complicated regarding their implementation in the domain based on ML. Analysis on literature review provide comparison study regarding ML approaches to locate students obstacle in related course. Table 1 provides the comparison. Collaborative learning appears to be among popular applied meaningful elements in the study.

Table. 1 Meaningful learning (ML) study using cognitive tool

Study	Learning aid strategy	ML element	Tool
[36]	Digital game	Constructivist	Advance organizer
[14]	Feedback to completed task	Active	Concept map
[37]	Select-and-fill-in knowledge	Active	Concept map
[38]	Active learning	Collaborative	Concept map
[39]	Teacher dominant	Purposeful	Advance organizer
[40]	Traditional teaching, traditional +relational framing, feedback	Active	Concept map
[41]	Feedback from peer and expert	Collaborative	Concept Map
[42]	Deep learning	Collaborative	Concept map

III. DESIGN AND DEVELOPMENT

The design and development of proposed model is part of research activities using ADDIE instruction model. ADDIE model is a systematic design guide using dynamic and flexible approaches to build effective teaching modules [43]. Figure 1 presents main activities in design phase i.e. modeling scaffolding for data analytics learning, identifying component attributes and frames for relevant ML strategies, and designing scaffolding for the strategy.

IV. COGNITIVE VISUAL SUPPORT MODEL

Cognitive visual support model focuses on data analytics knowledge construction and problem solving. Figure 2 present the model which consists of two main divisions namely Preliminary and Scaffolding. Preliminary part concerns on the knowledge background of learning process. Scaffolding part emphasizes the learning support.

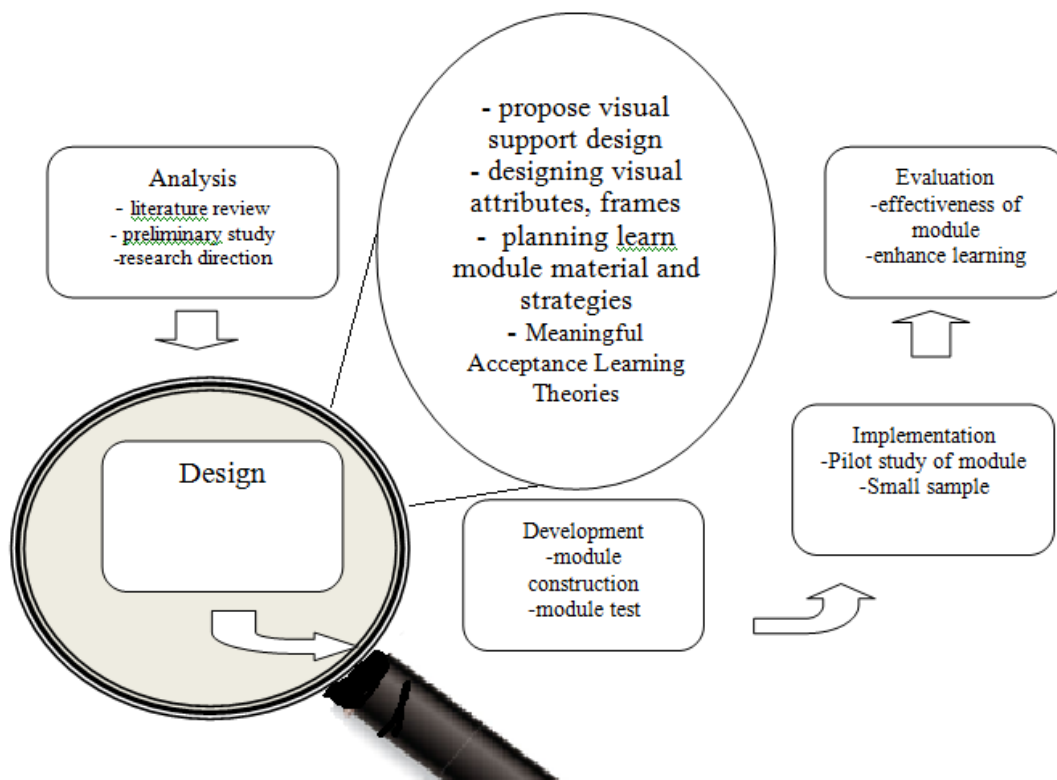


Fig. 1 Design phase in ADDIE instruction model

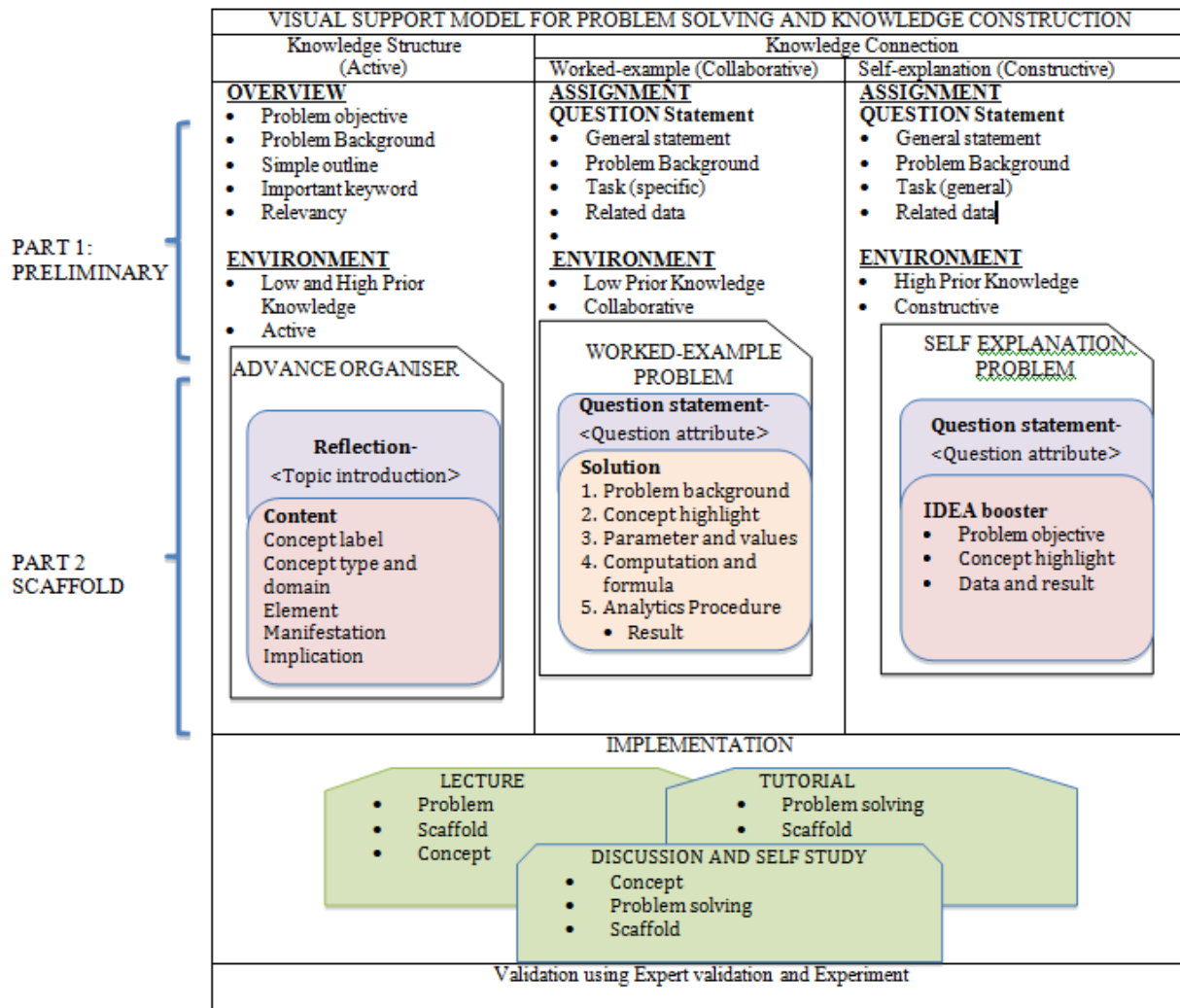


Fig. 2 Visual Support Model

V. DISCUSSION AND CONCLUSIONS

Visual cognitive support is among the proposed solutions for present scenario and issues in data analytic learning. Meaningful learning encourages cognitive visual tools to be used in classes to organize knowledge by linking new information with existing concepts in strong cognitive structure [44],[45]. To provide the support needed by students in their learning, specific scaffolding is offered to serve as guidance in developing better problem solving skills and knowledge construction [46]-[48].

In-depth understanding and concept integration are the major issues in data analytics learning and problem solving [4]. In order to help students gain meaningful learning and retain their knowledge, meaningful reception learning theory demonstrates advance organizer and concept map as among cognitive tools by linking new information with existing concepts in strong cognitive structure [11]. Meaningful learning strategies consider active, collaborative, and constructive to be embedded in the learning model.

Although this approach has been approved in previous analysis, the complicated implementation of these approach in data analytics coaching and learning has not considered. Hence, the analysis of literature has determined data analytics learning aspect and has construct scaffolding

model for data analytics learning and problem solving using the approved meaningful learning strategies.

This study offers visual framework as a collection of all needed ideas, concepts, examples, scenarios, as a designed and constructed material to contribute the support required by these students in data analytics learning. Three types of instructional design as visual cognitive support to build strong understanding structure i.e. active, collaborative and constructive are based on meaningful reception learning theory. The cognitive visual support model aims to assist instructors in establishing superior problem-based learning materials in their appointments and for contributing a instructional assistance for students constructing their knowledge and problem-solving skills.

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