Redefinition of the Parameters of Meaningful Mathematics Learning

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Abstract: This study employs an integrated research design with emphasis on quantitative design that determines the dimensions of meaningful learning experiences in Mathematics. There were primary data gathered in this study comprised the (a) data from the responses of the research participants from one on one interview, and (b) data coming from the responses in the survey questionnaires. The researcher used two types of instruments to gather relevant information in the realization of the research objectives. The first research instrument is intended to gather data from the responses of the research participants using in-depth interview. The second type of research instrument is the output of the quantitative part which is the survey questionnaire. The researcher used two data analysis for qualitative data and quantitative data. The use of these analyses was based on the assumption of the fluidity of the responses of the research participants and the statistical assumption of the statistical tool. The researchers used the Colaizzi's Seven Stage Process (1978) in analyzing the responses of the participants and Exploratory Factor Analysis in exploring and determine the factors of meaningful learning experiences. Based on the results and findings of the study, the dimensions of meaningful mathematical learning in mathematics comprises of six distinct factors which are theintentional meaningful learning, cooperative meaningful learning, real-life setting, derivative subsumption, advance organizer and educative processes.

Keywords: Meaningful Learning, Mathematics, Qualitative Research, Health Allied Students

1. Introduction

Educational systems deserve extreme focus and concentration. Its development is crucial since it determines the success of the students and the effectiveness of teachers. Generally, the betterment of education systems determines the betterment of nations **(Hanushek, 1995; Schendel & McCowan, 2016)**. More specifically, the economic and social development of a country relies on a highly skilled population that requires a certain level of skills in numeracy and literacy **(Hanushek & Woessmann, 2008; Hanushek & Wößmann, 2007; Robinson, 1998)**. Meaningful learning experience is concerned with subsumption which is a cognitive process that links the previous knowledge of the students to the understanding of the new concepts. The concept centers on relevant verbal learning or advance organizers (**Ausubel, 1963**). Also referred to as expository teaching, this proposition describes how an individual learns, along with the characteristics of an instructional process and how it can be organized **Hirumi (2002)**further cited meaningful interaction that is centered on the quality of communication on learning. Meaningful interaction do not just engaged on sharing personal opinion. However, the engagement should stimulate the learners' desire to learn, immerse them in productive educational tasks, and have a direct impact on their learning. Meaningful learning theory involves every approaches and principles that can be utilized in classroom environment where traditional face-to-face class occurs. This premise suggests that teaching-learning process entails determining advance organizers, incorporating them into relevant materials, and presenting these materials to the learners(**Babadogan & Ünalb, 2011**). Contrariwise, meaningful learning pertains to a type of learning in which the subject is taught in a comprehensive sense by means of incorporating the new concept into existing concepts or subjects (Novak, 2002) – significantly, the process involves building connections between the new concepts with the existing knowledge of the learners **(Romero, Cazorla & Buzón-García, 2017; Vrasidas & McIsaac, 1999)**.

Recent studies try to apply information or communication technologies to reinforce the accomplishment of meaningful learning **(Means, 2005; O'Dwyer, Russell, Bebell & Tucker-Seeley, 2005; Wenglinksy, 1998)**. Literature further indicate that creativity flourishes if learning experience is meaningful, and it build connections with the new experiences with information stored in long-term memory **(Ferguson, Clough & Hosein, 2010)**. Interestingly, it was averred that meaningful learning is active and constructive (**Yunianta, Yusof, Othman & Octaviani, 2012**), and emerges when people create knowledge in reaction to their surroundings, deliberate on their activities, and articulate what they have learnt. It is genuine and purposeful, taking place in a meaningful situation where learners are committed to achieve a goal **(Sharan, 2015)**. It is also cooperative, focusing on the socially mediated understanding and the concerted structure of knowledge**(Puntambekar, 2006).**

To offer purposeful mathematics tasks in classes remains a challenge, although various efforts were made to raise awareness particularly in the understanding of mathematics and its underlying concepts. It is also essential to share this awareness to the learners, particularly with the crucial function of mathematics in life**(Sparrow, 2008)**. Several instructors, on the other hand,do not even recognize the importance of mathematics. This can have detrimental impact on their teaching ability since they may not be able to relate classroom mathematics with real-world mathematics **(Cooney & Wiegel, 2003; Garri & Okumu, 2008)**. The primary goal of presenting mathematical exercises that generate meaningful learning experiences is to engage students intellectually, operationally, and affectively, as recognized in Attard's (2012) engagement framework. Cognitive engagement pertains to the learners having a "deep understanding of concepts and their applications; operative engagement – also known as the hands-on level – represents the active participation of a learner; and affective engagement is the value placed on mathematics by the student within their own life, where mathematics is considered significant beyond the classroom" (Attard, 2012). The affective engagement was stressed out by **Attard (2012)** and **Rukavina, Zuvic-Butorac, Ledic, Milotic and Jurdana-Sepic (2012)** to be the result of purposeful mathematics that encompasses real-world, significant and meaningful experiences which manifest learners interest. Additionally, learners are more inclined to obtain favorable attitude towards learning mathematics if they find it interesting**(Sparrow & Hurst, 2010)**and realize the relevance of mathematics learned at school compared to its application beyond the classroom **(Attard, 2012)**. This plays important role in the general mathematics achievement since it strengthens learners' willingness and desire to learn **(Mata, Monteiro & Peixoto, 2012; Pinxten, Marsh, De Fraine, Van Den Noortgate & Van Damme, 2014)**.

A certain level of knowledge of mathematics is essential for the successful participation in all aspects of the modern society **(Organisation for Economic Co-operation and Development, 2003)**. The Philippines joined the Trends in International Mathematics and Science Study (TIMSS) Advanced 2008 with only a total of 4091 students in their final year, from 118 science high schools, tested. The Philippines got 355 – way below the average score of 500. TIMSS advanced results showed that in general, Philippines is the least performing among ten (10) participating countries in Mathematics and in certain content areas, as well as in cognitive domains with reference to the average scale score and percentage of correct answers**(Ogena, Laña & Sasota, 2010)**. To boot further, this current situation where the national performance in mathematics is declining from 2008-2011 with the average of scores ranges 45 to 49.26% **(del Rosario, 2012)**, is alarming and untenable. The low achievement in mathematics can be explained in the low interest of the subject **(Selamat, Esa & Saad, 2011)**.These problems to the educational system that emphasize practice without incorporating and applying the concept. A study also revealed that poor performance in Mathematics is related with the way the learners build meaningful experiences**(Middleton &Spanias, 1999)**.

Within the premise of higher education institutions in the Philippines, most students who were advised to shift the program or out of the institution failed the subject twice or failing 20% of the total units is due to the institutional policy of failing the repeated subjects. Many students find difficult to connect Mathematics to the other field of sciences and its application for their future work **(Gainsburg, 2008; Nicol, 2002)**. Sometimes, this subject hinders them to graduate on time and worse, removes them from the program **(Boaler, 2015)**, resulting in a decrease, say, of the potential medical and healthcare professionals. Teachers are then challenged to stimulate learners' engagement in meaningful mathematical education confined within school's educational system, and discover means to address the paradigm of meaningful learning experiences. Moreover, in terms of availability of publications, there is a limited number of recent researches on meaningful mathematical learning experiences. The above scenario prompted the researcher to explore the meaningful learning experiences.

2. Significance Of The Study

This study may be useful to San Pedro College, specifically its students, administrators, teachers, and future researcher:

College Students. This study may help the students in improving their understanding in building mathematical concepts that are relevant and aligned to their respective field of endeavor. Further, they will be helped by the teacher by providing them suited mathematical instruction and strategies according to their respective needs.

College Teachers. This study is helpful as the results of this research may provide them with a clear picture as for how they can improve their respective learning conditions to fortify the learning experiences and strengthen motivation of their students in learning Mathematics. The results of this study may also help teachers become more engaged and active in taking part in the role of making the teaching and learning meaningful in Mathematics discipline.

School Administrators. This study is beneficial to the school administrators in order for them to design intervention programs that may help improve the student's learning environment and learning outcomes in the Mathematics.

Curriculum Planners. This study may help the curriculum planner to come up with authentic learning processes that will concertize the intended learning outcomes necessary for student success across an entire curriculum.

Academic Community. This study may help the academic community on how health allied students learn mathematics meaningfully. The dimensions that were formulated may serve as the basis for program development to help students with a low interest in the students and poor mathematical skills.

Researcher. This study will be helpful for the researcher to come up with a concrete evidence on how to teach his student in Mathematics that will result in meaningful learning experiences.

Future Researchers. This study may challenge the future researcher to explore the same topic to either replicate the study using other research methodologies and substantial sampling population to validate the results of the study.

3.Review Of Related Studies

3.1 Theoretical Basis of Meaningful Learning

A cognitive approachof learning from instruction entails comprehensive understanding on the involvement of learners' cognitive processes with learning treatments and resources. The meaningful learning proposed by Ausubel, also refers to as cognitive learning theory, define and explains the reason of how an information becomes memorable and significant for the learners. Ausubel assumes that an individual can learn best if they integrate, or assimilate, new information with previous knowledge. Within this approach, learning becomes more meaningful as students develop their own interpretations of new information, increasing the likelihood of retention **(Ausubel, 1963)**. He further construed that meaningful learning, which entails longer retention compared with memorization, happens when a person associate new concepts with pre-exiting recognized concepts. Then modifications in our cognitive structure occur, concepts are transformed, and new connections are formed. Then it becomes a useful component that consent real learning, where greater retention and transference with real situations take place**(Ausubel, 1963)**.

Ausubel's model provide readers with an impression of a carefully crafted, logically consistent proposition which characterizes the cognitive processing of information. It also specifies how instructional materials should be designed to strengthen assimilative ties with the learners' knowledge of a certain information along with related material being learned. Implementing these specially developed instructional materials is likely to extend the retention time and improve the learner's capacity to recall previously learned material.

The controversy centers on several concerns regarding the theoretical and empirical components of Ausubel's model. Initially, his theory on meaningful verbal learning is confronted with confusions **(Anderson, Spiro, & Anderson, 1978; Ausubel, 1978; Ausubel, Sullivan, & Ives, 1980)**. Also, it is unclear how the theory articulates suitable instructional material design, particularly advance organizers**(Barnes & Clawson, 1975; Hartley & Davies, 1976)**. Lastly, several authors appear to regard Ausubel's theory as inadequately designed explanatory model of human learning since it confused the logic of theory development with the outcomes of research when analyzing the theory's predictive capacity**(Anderson, Spiro, & Anderson, 1978)**, although some researchers think of it as reasonably inviolate**(Lawton & Wanska, 1977)** and therefore do not require empirical validation.

Theoretical discourse of Ausubel's model largely confined to correlative subsumption concept, and it is associated with the subsumption that is commonly used to define cognitive processing. Almost every researches that is derived on Ausubel's work has attempted to establish the effectiveness of advance organizers, which are often designed based on the principles of correlative subsumption. As a result, organizers have been considered as the only empirical way of examining Ausubel's complete mode's explanatory value.

The theory of Ausubel was extended by Novak **(2002)**. Novak introduced concept mapping that is a very important tool in creating meaningful learning experiences. Concept maps are useful materials to visually represent the knowledge. Graphic designs represent a network that portrays different concepts linked with nodes and their relationships are defined by arrow symbols. In addition, **Marra, Jonassen, Palmer and Luft (2014)** suggested the technologies can be used for the learners to build meaningful learning experiences. Technologies are expected to stimulate learners particularly with articulating and reflecting their ideas. Moreover, learners develop a model of meaningful learning experiences that are active, productive, cooperative, genuine and intentional, which was attained with the involvement of technology.

In the context of classroom application, some curriculum professionals and instructional designers recommend employing Ausubel's design of classroom instruction(**Joyce & Weil, 1980**). Majority of assumptions pertaining to the application of cognitive assimilation and hierarchical knowledge retrieval are currently debatable, and t is unknown with confidence whether advance organizers assist in learning. Therefore, while applicability of the model in classroom setting is possible, the actual implementation would require careful planning(**Joyce & Weil, 1980**).The amount of effort required may not always be compensated by new learning facilitation.

3.2 Indicators of Meaningful Learning

Many educators believe that students learn best in the accordance with their needs and readiness. In this regard, students need the help of their teacher or classmates in mastering any mathematical concepts. Cooperative learning was introduced to help students learn better with the help of their peers. **Slavin (2014)**referred cooperative learning to "an instructional strategy in which small groups of students work together on a common task."This teaching style is a great technique to encourage learners to think logically instead of depending on the teacher for solutions.

Cooperative learning creates meaningful learning experiences of the students incorporated with effective instructional approaches **(Housinger, 2002)**. The ideal outcome of the cooperative learning or small-group learning is having the students working with others, building on and sharing and justifying the ideas, therefore, creating a "deeper understanding of the concept being explored." Moreover, other instructional approaches such as whole-class orientations and discussions, which should be conducted by the instructor, should always be used in collaboration with this method.

Johnson, Johnson, and Stanne (2000) also postulated that cooperative learning approach has one of the most diversified output. Learners can work one-on-one with their peers to be able to identify their strengths and what they can provide as a member of the group. The cooperative learning will result in diverse outcomes improving learner's achievement, higher-level reasoning, retention, time on task, transfer of learning, achievement motivation, intrinsic motivation, continuing motivation, social and cognitive development, moral reasoning, perspective-taking, interpersonal attraction, social support, friendships, reduction of stereotypes and prejudice, valuing differences, psychological health, self-esteem, social competencies, internalization of values, the quality of the learning environment, and many other outcomes. With so many positive outcomes, it is easy to see why instructors would want to use this kind of instruction in their classrooms.

Also, several works (e.g., **Artzt & Newman, 1990; Sutton, 1992**) highlighted four significant conditions that incorporate a cooperative-learning environment. First, learners study in small groups involving two to six members. Second, learning activities where learners are involved entail that each learner should mutually and positively rely on each other and in their group's activity.Third, the educational environment provides an equal opportunity for all members of the group to converse with one another about the learning tasks and stimulates them to convey their ideas in a variety of ways. Lastly, every group member has an opportunity to adhere to group work and is responsible for the group's learning progress.

Cooperative learning is a firmly instituted pedagogy that can be found in both classroom environment and curricula. This teaching strategy helps the student to develop holistically. Though there are debates for this type of teaching strategy, many researchers (**Johnson & Johnson, 2008, 2014, 2017**) still claimed that the application of cooperative kearning, particularly in mathematics classroom, resulted to an increase in motivation, academic achievement and social skills of the learners(**Nind, Wearmouth, Collins, Hall, Rix & Sheehy, 2004**). Thus, it should be noted that applying this type of teaching strategy requires careful planning, implementation, and assessment to determine its effectiveness in the development of the students.Before attempting to adopt cooperative learning, instructors and educators must first understand the challenges and tensions that might occur in their classroom.

In order to be useful in real-life situations, mathematical learning experiences must explicitly connect and require mathematical concepts, capabilities, and approaches to valuable, relevant, and meaningful situations **(Garii & Okumu, 2008)**. This operational definition of authentic learning experiences in mathematics has been the basis of the several organizations and standards, for instance the **National Council of Teachers of Mathematics (2002),**which emphasizes the goal of enhancing the knowledge on the applicability of mathematics in the daily life of the employees.

Rule (2006) formulated the components of authentic learning which pertains to an activity that covers actual issues and which imitates the output of some professionals; the activity entails output presentation to audiences outside classroom premises; it utilizes open-ended questions, thinking skills and meta-cognition; learners participate in social learning discourse within a community; and learners focus their learning in their project work.

However, there is still criticism on the realization of the authentic learning in the classroom because of their incapability to provide suitable and updated learning environment. Some literature even cited that academic institutions only prepare children for school(**Jonassen, 2003**), that academic environment is being prescriptive (**Gee, 2004**), it lacks importance on the life of the learners(**Gee, 2004; Oblinger, 2005**), that its existence implies more control than enhancement on learning(**Nair & Gehling, 2008**), and that academic institutions are challenged to recognize that there are other means of literacy beyond the classroom**(Barton, Hamilton, Ivanič & Ivanič, 2000)**. Schools and teachers are compelled to recognize the demand for change and to comprehend the expanded meaning of litercy(**Leu, 2002; Leu & Coiro, 2004),** and to capture the opportunities in order to create learning experiences that accurately represent the community practices in which the learners are (and will) required to engage(**Mantei & Kervin, 2009**).

Authentic learning experiences are well-crafted exercises that most learners find interesting, and, perhaps most crucially, enable students to direct their own learning. They involve observation, explorations, experimentations, problem-solving, modeling, performances and creative interpretations(**Ladwig, Lindgard, Mills & Land, 2001**). Furthermore, learners must learn how to apply a skill in order to improve their ability and understanding, not merely how to employ a technique that they have "learned."Since rote memorization is never enough, Skills such as critical thinking, problem-solving, and collaboration may be employed by learners for them to find solutions. In information inquiry, authentic learning took place at the convergence of workplace information problems, personal information demands, and academic information difficulties or assignments in information inquiry **(Callison & Lamb, 2004)**. **Gulikers, Bastiaens, and Martens (2004)** expressed that organizations sometimes contend on a fact that learners have greater knowledge but are less competent. Learners are accustomed to seeing a problem that fits into a mold and into which they can input a "fact." Instead of solving a problem, they have learnt to construct a solution.

In connection with the cognitive processes during the act of learning, cognitive research focuses on the information processing model. In order to construct a memory, current information is processed and recognized in sensory memory before being transmitted to working memory for further meaning-based analysis. Information that is significant to a person's objectives is thus maintained in the long term-memoryfor an indefinite period until it is required(**Bruning, Schraw, Norby, & Ronning, 2003**).

Moreover, the encoding theory **(Bruning et al., 2003)** states that the way the children encode to-be-remembered memory creates a huge influence on how good they are at remembering. This is the reason why children are able to learn better through mnemonics, like creating rhymes with words or illustrating imageries. In the premise of complex knowledge, encouraging learners to involve in active learning is relevant. It improves their active learning, particularly enhance their schema activation, knowledge elaboration and organization, and deeper level of processing.

Employment of advance organizers entail an approach that establish relationships among concepts and connects the knowledge of the learners with the ideas they are to learn, hence enable easier learning task. More so, it aids the long term memory process by allowing information to enter through the use of working memory. Advance organizers act as a subsume that helps in the retrieval of old information from the long term memory, then connect it with incoming stimuli to regulate the understanding of new knowledge **(Millet, 2000)**.

Ausubel (2012)further expounded the advance organizers model through his assimilation theory of meaningful learning and retention. He claims that learning is built on schemata, or mental structures that learners use to integrate their perceptions of their surroundings. He also emphasized that learners understand best when they find meaning in what they are learning, and that using advance organizers can help learners activate existing knowledge in a new educational environment, making the process more interesting to them.

The meaningful mathematical learning experiences make students engage in the construction of learning from the different teaching strategies of the teachers. This can be attained by means of cooperative learning where learners share their ideas and communicate their experiences and understanding of the topic. With the use of the advance organizers, linking the network of interconnected topics of mathematics is easier to understand. Further, the application of the mathematical concepts in the real-life setting as well as in the classroom setting boosts the students to study.

4.Objectives Of The Study

- To explore the views of the research respondents on meaningful learning experience in Mathematics.
- To determine the factors of the meaningful learning experience of students in Mathematics.
- To determine the model of meaningful learning experience of students in Mathematics.

5.Hypotheses Of The Study

The study hypothesized that Meaningful Mathematical Learning can be explained by active meaningful learning, constructive meaningful learning, cooperative meaningful learning, authentic meaningful learning and intentional meaningful learning.

6.Population And Sample

Through purposive sampling technique, the researcher interviewed 13 students who passed mathematics, seven students who failed mathematics from different departments and three Mathematics teachers. These number of research participants is enough to saturate the information on meaningful mathematical learning **(Forman, et al., ,2008)**. Purposive sampling is appropriate since the study requires the personal knowledge and actual experiences of the participant based on the purpose of the study. Selection of the student participants was based on the criteria that they passed mathematics, they failed mathematics and they enrolled in a health allied courses (Pharmacy, Nursing, Physical Therapy, Respiratory Therapy and Medical Laboratory Sciences). Further, the selection of the teacher participants was established on the criteria that they have been teaching for five years in the health allied courses. All participants for the qualitative and quantitative phase are all health allied students.

The second phase of the study required random sampling technique since it employed testing the hypothesis whether the model is the best fit or not. **Ferguson and Cox (1993**) suggested a minimum of 100 students for this analysis. However, the researcher came up with 404 respondents for Exploratory Factor Analysis (EFA) and 204 for Confirmatory Factor Analysis (CFA). This number of respondents is enough to come up with different dimensions of meaningful learning experiences.

6.1.Statistical Techniques Used in the Present Study

Qualitative Data. In analyzing the data and the results gathered, the researcher evaluated it and sees if it accomplishes the intent and the objective of their study, which is to determine the perspective of the meaningful mathematical learning. The researchers used the **Colaizzi's Seven Stage Process (1978)**, which is outlined as follows: The obtained data will be reviewed by the researcher. Within this method, researcher is able to gain an emotion on participant's inherent meanings. The researchers went back to the data to focus on the most essential parts of the phenomenon being explored. Significant statements were extracted from the data and the researcher establish meaning within the context of the subject's term.Every meaning derived from a number of interviews were organized to form a collection of themes. This process identified prevalent patterns or trends within the data. A detailed, analytic description was compiled of the subject's feelings and ideas on each theme. This is called an exhaustive description. The researcher identifies the fundamental structure for each exhaustive description. Results from careful analysis were taken back to the respondents to review if the researcher missed or omitted some information. This process refers to as member check.

Quantitative Data.The researcher applied statistical tools such as exploratory factor analysis (EFA), Cronbach's alpha, and the confirmatory factor analysis. EFA was used to explore and determine the factors of meaningful learning experiences. An Exploratory Factor Analysis pertains to the orderly generalization of interrelated components. This measure has been employed to investigate underlying components of a set of observable variables without enforcing a predetermined framework on the result**(Child, 1990)**. This statistical tool will answer the subproblem "what are the characteristics of the meaningful learning experiences of the college students". The data was encoded in spreadsheet form before they were exported to the software. During the exploratory factor analysis, the researcher considers the mean imputation in replacing missing data on a variable with the mean of non-missing data for that variable **(Allison, 2001)**. This approach is one of those that replace missing information on a variable with a measure of that variable's central tendency.

The data were analyzed using the data reduction choosing the factor analysis as an option. A principal component analysis is used as extraction method followed by orthogonal (VARIMAX) with Kaiser normalization rotation method. For each sample, the magnitude of the eigenvalue should be greater than 1.0, the factor loadings of the individual item and the number of the item incorrectly loading on a new factor will be recorded. Then an assessment of the correctness or incorrectness of the factor structure was made. If a factor analysis for a particular sample produced three factors and the items loaded together on the correct factor (together on the single factor) that the analysis will be considered to have produced the correct factor structure. If the result of factor analysis leads to unfitting number of factors with eigenvalues greater than 1.0 or if one or more factor failed to load on the appropriate factor, analysis will then be treated to have come up with incorrect factor structure (**Turker & MacCallum, 1997**). With the extracted factor structure, the researchers then combined all the items with correct factor loading. In this study, a variable that yields factor loading of 0.60 **(Costello & Osborne, 2005)** and describes as "fair" **(DiStefano & Hess, 2005)** and no cross-loading to other factor was used.

The second statistical tool was the Cronbach's alpha which measures the internal consistency of the questionnaires. Cronbach's alpha is an index of reliability associated with the variation accounted for by the true score of the underlying construct. The construct is the hypothetical variable that is being measured **(Hatcher & Stepanski, 1994)**.

The third statistical tool was the confirmatory factor analysis (CFA), which is used to test whether measurement model is consistent with EFA results. Typically, CFA is used in a deductive mode to test a hypothesis regarding unmeasured sources of variability responsible for the commonality among test scores. The number of factors and pattern of loading are hypothesized before the analysis and placing numerous restrictions on the solution (Hoyle & Duvall, 2004). If constraints imposed on the model are inconsistent with the sample date, the results of the statistical model fit will indicate a poor fit, and the model will be rejected. CFA is applicable for the evaluation of construct validity, which address the degree where a hypothetical construct associates with one another construct of meaningful patterns. Confirmatory factor analysis can be used to assess construct validity by integrating numerous constructs into a single model and compare the structure of covariance among factors reflecting the constructs to a pattern anticipated by a theory about the connections between the constructs**(Hoyle, 1995)**. Before the model fitting, the researcher run Mahalanobis distance test to determine the outlier responses. The outlier responses were deleted to follow the normality of the data.

There are several evaluations of the measurement models based on different authors. Accordingly, there were between two main criteria, the goodness of fit index (GFI) and the root mean square error of approximation (RMSEA). GFI ranges from zero to 1.0 and indexes the relative amount of the observed variance and covariance accounted for by the model, values greater than 0.9 are viewed as indicative of a good fit **(Tanaka, 1993)**. RMSEA indexes the degree of discrepancy between the observed and implied covariance matrices per degree of freedom. The minimum value of RMSEA is zero; **Browne and Cudeck (1983)** proposed 0.05 as a value indicative of close fit, 0.08 as indicative of marginal fit and 0.10 as indicative of poor fit of a model considering the degrees of freedom of the model. Also, fitness indices that reflect how to fit are the model to the data at hand. Researchers do not agree on which fitness indices to use**Hair, Ringle and Sarstedt (2012),** however,**Holmes-Smith, Coote and Cunningham (2006)**proposed the application of no more than one fitness index from each category of model fit. There is three model fit categories: absolute fit, incremental fit, and parsimonious fit. The choice of the index to choose from each category to report depends on which literature is being referred. The information concerning the model fit category, their level of acceptance, and comments are presented in Table 1.

Table 1. The three categories of model fit and their level of acceptance

Name of category	Name of Index	Level of Acceptance
1. Absolute fit	x^2 RMSEA GFI	p-value > 0.05 RMSEA < 0.08 GFI > 0.90
2. Incremental fit	AGFI CFI TLI NFI	AGFI > 0.90 CFI > 0.90 TLI > 0.90 NFI > 0.90
3. Parsimonious fit	Approximate x^2	x^2/df < 3.0

6.2.Data Analysis and Interpretation

6.2.1 Qualitative Results

The presentation of the findings deals with the results of the qualitative data analysis based on the interviews of the teacher, students who passed the subject and students who failed the subject. The researcher does the preliminary English translation of the other language data based on the original meaning of the responses. Further, the researcher quotes verbatim from the original transcript.

Research participants agree that meaningful learning can be achieved if teachers can provide many examples which are relevant to their respective field. Further, they emphasized that learning is meaningful if students can manipulate their own understanding through solving different problems. They recognized the individual differences of the students in terms of understanding the concepts thus teachers employ different styles in presenting the lessons. The following are the responses of the teachers:

Teacher 1 said:

"So basically, I give them the concepts and how to the procedure of doing the calculation and after which I will explain to them how you can apply this in the real world."

Teacher 2 straightforwardly said:

"Of course, I will let my students solve problems... Most probably I have to teach each student or I have to give time to my student to participate in the solving of the problem especially board works because that's the time that they could express to their selves and how to solve a particular problem."

Active learning is achieved by students through different examples given by the teachers. Through observation and practice intensifies its retention in the memories of the learners. However, they felt that giving examples and explaining the computation was not enough for them to really understand the concept. They believe that watching videos can reinforce their understanding in the different mathematical problem. Further, it was stressed the crucial function of the teacher as facilitator in the educative processes. The following are the responses of the students who failed the subject:

Student 3 expressed:

"*He gives us examples and allows us to answer them afterward, that's all*."

Student 4 shared:

"*Sometimes they give examples and tell us to answer them afterward, or sometimes they just discuss them*."

Student 5 explained:

"*They have different ways of teaching. For one, they use a certain video that teaches how to do shortcuts. They also teach us techniques on how to solve which can be used during exams.*

Teachers recognize the importance of connecting new topic from the existing knowledge of the students. Both teachers used Socratic method by asking the students the previous concepts and connecting it to the new topic. Sometimes if the students cannot recall the concept the teacher will explain it and that instance the students will recall the concepts. The following are the responses of the teachers:

Teacher 1 said:
"You must give them ahh brief ahh what's this a brief summary of what they must learn and how they should apply this and then we go into the details afterwards. So, for basic mathematics, there should always be concept mapping, because ahh as we all know you cannot understand the next math without understanding the previous so, you should emphasize to them that there is connectivity between all these topics from the previous. Aside from allowing them to recall, because sometimes they cannot recall and then I let them explain what they have learned and then from the moment that I realized they have learned what they have ahh what we have discussed last time then I will begin discussing the new topic."

Students who passed Mathematics recognized the importance of connecting the previous knowledge to the new concept. As a result, learning is easier to understand. They also acknowledge the importance of review before each discussion.

Student 1 described:

"*For me, yes, because we have to be study ahead every new lesson that is to be discussed, it's like saying that you should not go to a war without a bullet."*

Student 2 said:
"*So, it's just a way of like assessing if we know anything about an aspect of a topic."*

Research participants see meaningful learning as the actual application of the mathematical concepts in their major subjects both lecture and laboratory and in the real-life setting. They detailed how these strategies impacted the retention of the concepts. Further, they believed that mathematics does not develop the cognitive dimension in terms of higher and lower order thinking skills, but it will develop their psychomotor and affective skills.

Student 1 explained:
"So for me, in every aspect that you look into your life, there will always be math and it is meaningful in a way that it is not only bounded in the four corners of a room, it applies in your daily living."

Student 9 explained confusedly:

"I think they have different, ahh, intents no? so, the numbers and variables they more ahh more on focused on the critical thinking while the ahh applications in real life is another thing where you can apply what you learned."

Students shared their teaching and learning experiences in mathematics as multifaceted. They see that every educative process as a unique experience from one teacher to another teacher. Board word does not help in building the concept and establishing meaningful learning. However, they believed that every student is unique, group work may not help them sometimes.

Student 1 expressed:

"*Usually in math class, my classmates would get together and teach each other how to solve and such. It's not like other subjects like Philosophy or anything where they would only talk to each other and don't mind about the subject. When it comes to math class, we'd be anxious when we try to learn."*

Student 6 said:

"*In a way that your classmates and teachers help you."*

The following are the responses of the students who passed the subject:

Student 9 said:

"*We learned mostly about teamwork and doing your part and helping each other out in ahh, solving the problems*."

Student 12 expressed:

"*Board work, groupings? For me, it depends. Sometimes, I am the type of person who prefers to work alone."*

Students recognized that learning the concept does not stop in one lecture session. In a form of assignment, students work independently at home and the teacher will check it on the next day if they really get the concept. The following are the responses of the students who failed math.

Student 1 narrated:

"Before he gives a quiz, he'll give us an assignment to practice at home. By the next meeting, he will give us a quiz. Then, when you can do the assignment, you can also do the quiz. Sometimes he just replaces the numbers in the assignments and give it to us as a quiz."

Student 4 said:

"Sometimes they give examples then they let us answer. Sometimes they just discuss the topics."

Research participants view the meaningful mathematical learning in a form of active meaningful mathematical learning, intentional meaningful mathematical learning, cooperative meaningful mathematical learning, authentic meaningful mathematical learning, activating the prior learning using advance organizer and review and motivation.

Research participants see important scientific learning encounters as organized ideas that are interconnected from one theme to alternate subjects. They trusted that acing a solitary point is essential in understanding the new subject. In this specific circumstance, propel coordinator was extremely useful in spanning the two measurements of past and new ideas. Further, they trusted that, while learning in the educative procedure, exercises ought to be purposeful that is coordinated to the goals of the theme. Learning forms is significant in the sense understudies occupied with the platform of the new thoughts which is pertinent in the real-life setting.

6.2.2Quantitative Results

A total of 26 items were deleted the items with coefficient below 0.80. Specifically, 6 item statements for active meaningful learning (1, 2, 3, 11, 13, and 16), 4 item statements for authentic meaningful learning (5, 7, 8, 9), 1 item statement (3) for cooperative meaningful learning, 8 item statements (2, 3, 4, 6, 7, 10, 12, and 13) for motivation, 4 item statements (2, 3, 4 and 12) for intentional meaningful learning and 2 item statement(7, 10) for subsumption were deleted.

Shown in Table 2 is the number of items of the subscale of meaningful mathematical learning in the three-phase item development. In phase 1, items were generated from the literature reviews and in-depth interviews with the research participants. With the help of the item writer who is an expert in measurement and evaluation, 76 item statements were formulated. This phase ensures the coherence, validity, and accuracy of each factor of meaningful learning in Mathematics. In phase two, the items were checked by the research adviser to ensures the content validity and objectivity of the items. One item was deleted in the dimension of motivation. The last phase is the experts' validation.

Table 2. Number of items of the subscale of meaningful mathematical learning in the three-phase item development

Sub-scale	Number of Items		
	Phase 1 (Literature Analysis and in-depth Interview	Phase 2 (Adviser's Revisions	Phase 3 (Experts Validation)
Active Meaningful Learning	16	16	10
Authentic Meaningful Learning	13	13	9
Subsumption	11	11	9
Intentional Meaningful Learning	12	12	8
Cooperative Meaningful Learning	9	9	8
Motivation	15	14	6

Table 3 present the results of the exploratory factor analysis of the active meaningful learning. Using the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO=0.793) to measure the adequacy and suitability of the exploratory factor analysis involving 404 respondents. The findings show that the data is suitable for exploratory factor analysis since it surpassed the minimum requirement of 0.5. The finding also tells us that the data is enough to have a distinct factor **(Kaiser, 1974).** The Bartlett's Test of Sphericity shows that R-matrix is not an identity matrix. It also shows that we do have patterned relationships amongst the variables ($p<0.01$).

Table 3. Factorability of the exploratory factor analysis data

Sampling Method	Approx. x^2	df	KMO	Sig
Kaiser-Meyer-Olkin Measure of Sampling Adequacy			0.793	
Bartlett's Test of Sphericity	3300.70	210		0.00

Exhibited in Table 4 is the factor loadings and the thematic analysis of the items after the exploratory factor analysis. In table 5, 21 items clustered in the six factors or dimensions of the meaningful learning in Mathematics. An item having the factor loadings below 0.6 were deleted. The factor loading value of 0.60 or higher is considered as very strong and thus retained.

Table 4. Factor Loadings of the Meaningful Learning in Mathematics

Item Statements	1	2	3	4	5	6
IN6	0.838					

IN11	0.836					
IN7	0.767					
IN8	0.723					
COO4		0.856				
COO2		0.826				
COO1		0.772				
COO7		0.619				
AT11			0.801			
AT6			0.722			
AT12			0.717			
AT4			0.668			
SUB9				0.805		
SUB8				0.784		
SUB11				0.757		
SUB6					0.883	
SUB5					0.874	
SUB2					0.659	
AT2						0.805
AT1						0.748
AT3						0.666

Thematic analysis of the items after the exploratory factor analysis. The first factor (F1) has accumulated 4 final items (IN6, IN11, IN7, and IN8). These items will measure the *intentional meaningful learning*. The second factor has obtained 4 item statements (COO4, COO2, COO1, and COO7). These items will measure the *cooperative meaningful learning*. The third factor has obtained 4 items (AT 11, AT6, AT12, and AT4). These items will measure the *authentic meaningful learning in the real-life setting*. The fourth factor has obtained 9 items (SUB8, SUB8, and SUB11). This will measure the *derivative.* The fifth factor has obtained 3 items (SUB 6, SUB 5, and SUB2). These items will measure the *advance organizer.* The last factor obtained 3 items (AT2, AT1, AND AT3). These will measure the factor *educative processes.*

The use of EFA reduces items which have low factor loadings and similar meanings with the other items. The extraction method used in this research is the principal component analysis which results in the two-rotation factor analysis. Table 7 shows the items elimination for low factor loading and inter-factor convergence using Varimax Rotation. First rotation came up a factor of 10. Items AT10, AT7, COO6, COO5, COO8, COO9, MV14, MV9, MV11, MV1, MV10, MV8, IN9, IN10, IN1, IN5, SUB3, SUB1, and SUB4 were eliminated. No item statement was eliminated in the sixth factor loading.

Table 5. Thematic Analysis of the Items Extracted by EFA

Themes	Code	Item Statements
Intentional	IN6	6. I find YouTube helpful in showing the easiest way to solving the problem.

Meaningful Learning	IN11	11. I look for other references like YouTube on how to solve problems at home.
	IN7	7. I am encouraged to use different materials as a reference in understanding the concept.
	IN8	8. I access materials, investigate how things work and explore puzzling questions.
Cooperative Meaningful Learning	COO4	4. I get relevant information in mastering the concept from my classmates.
	COO2	2. I understand mathematical concepts better during group works.
	COO1	1. I learn as I listen to my classmates' explanation of solving the problem.
	COO7	7. I learn teamwork by doing my part and helping others in solving the problems.
Application to Real Life Setting	AT11	11. I can apply my mathematical learning in my everyday activities.
	AT6	6. The application of the numbers and variables develops the critical thinking skills and application to real life.
	AT12	12. I can use my mathematical learning to help me examine problems from different perspectives.
	AT4	4. I use mathematics in checking and counting patients in the hospital.
Derivative Subsumption	SUB9	9. I see the connections of the different mathematical concepts.
	SUB8	8. I use previous problem-solving strategies in solving the new problem
	SUB11	11. I use my previous experiences in understanding the new mathematical topic.
Advance Organizer	SUB6	6. Classroom reviews make new concept easier.
	SUB5	5. Classroom reviews ensure learning of the previous topic.
	SUB1	1. The brief summary of the topic helps me show the expected learning outcomes towards the end of the discussion.
Applicability to Other Subjects	AT1	1. I can solve Chemistry problem using Mathematical concepts
	AT2	2. I use the concept of substitution in medical ventilation in terms of flow in liters per minute.
	AT3	3. I can solve word problems in College Algebra that can be used in major subjects.

Prior to conducting CFA, the researcher conducted reliability testing to ensure that the items are consistent. **Thompson and Levitov (1985**) and**Matlock-Hetzel (2010)** proposed that the quality of the test can be evaluated by means of computing reliability. It means consistency in results whenever it is delivered to same groups in same conditions. Reliability is the degree to which an assessment constantly measures whenever it measures **(Airasian & Russell, 2008)**. Shown in Table 6 is the level of reliability of the meaningful learning and its dimensions. Using Cronbachs' alpha, the six dimensions has the reliability coefficient of 0.81 to 0.91. The overall reliability is 0.94. If the value of reliability is above 0.70, the test is very good **(Taber, 2018).**

Table 6. Internal consistency by dimension meaningful mathematical learning

Sub-scales	Cronbach's alpha	Number of Items
Intentional Meaningful Learning	0.81	4

Application to Real-Life Setting	0.88	4
Cooperative Meaningful Learning	0.85	4
Derivative Subsumption	0.89	3
Advance Organizer	0.91	3
Applicability to Other Subjects	0.90	3
Overall	0.94	21

Confirmatory Factor Analysis (CFA) examines whether measurement model is consistent with the Exploratory Factor Analysis that was run in the previous section. Typically, CFA was employed in a deductive mode to examine a hypothesis pertaining to the unmeasured foundations of variability accountable for the commonality among test scores in terms of relationships of the constructs. The number of componets and pattern of loading are postulated before conducting the analysis and assigning numerous limitations on the solution **(Hoyle, 2000)**. Assumed that parameters imposed are inconsistent when compared with the sample data, analysis of statistical model fit would reveal a poor fit, resulting to rejection of the model.

Before conducting CFA, the researcher considers some assumption given by **Hoyle (2000).** First, in terms of sample size, an N of at least 400 is preferable, because indexes of fit begin to evince their asymptotic properties at this number **(Hu, Bentler & Kano, 1992)**. Second, in terms of distribution property, CFA is a multivariate statistical model and, therefore, it is the multivariate distribution of the data that affects estimation and testing. The third is the scale of measurement. Common estimators such as maximum likelihood assume that indicators are measured on a continuous scale **(Jöreskog, 1969)**. When this happens, indicators are considered to be coarsely classified. **(Bollen & Long, 2002)**. Finally, as to the kind of indicator, factor analytic approaches have postulated that indicators are determined by factors. Within that proposition, indicators are presumed to indicate factors whose presence may be deduced from covariation pattern of the indicators.

Following from that assumption, indicators are assumed to reflect factors, whose presence is inferred from the pattern of covariation among the indicators.Shown in figure 1 is the model fit indices of the meaningful mathematical learning (six-factor rotation). Using AMOS 20 software, the obtained values were χ^2/df = 2.61, GFI = 0.831, CFI = 0.911, TLI = 0.893 and RMSEA= 0.089. Since some of the measure of good fit does not satisfy the requirement the researcher correlated the error term as provided by the modifications index.

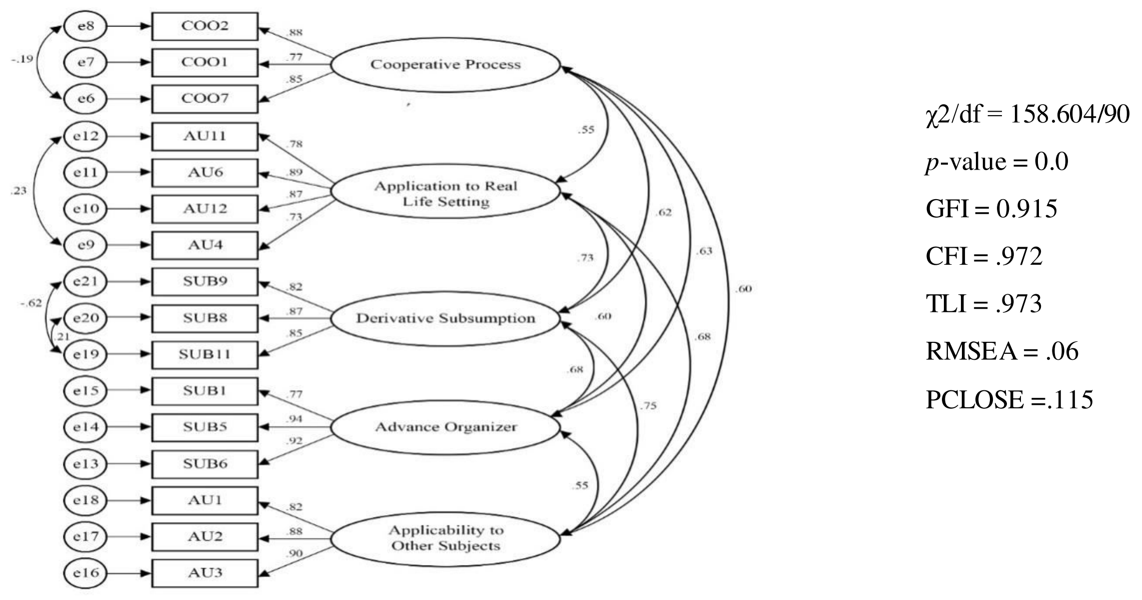

Figure 1. Five-factors first-order CFA model of meaningful learning in mathematics

7.Recommendations

- The literature review and the in-depth interviews shed the light of the presence of the dimensions of meaningful learning in Mathematics, however, using the exploratory factor analysis and confirmatory factor analysis did not prove the presence of some of the dimension of the meaningful learning experiences as reflected in the literature and the responses of the research participants. This means that the resulted dimension of meaningful mathematical learning experiences is a unique paradigm of higher education institutions. Further, this tool can be used by assessment practitioners in interpreting the results when utilizing this instrument for diagnostic purposes among college students with deep issues. These measures have to be utilized, making sure that validity and reliability will be established in every context where the scale will be used.

- To determine the utility of instrument, further validation on the usefulness of the tools is recommended by comparing the scores to the other Mathematical instrument like Math Anxiety and Math Resilience which can be a good source of evidence validity of the Meaningful Mathematical Learning Experiences. Mathematics teachers may be given seminars and training in suited teaching strategies to help the students in creating meaningful mathematical learning experiences based on the formulated model of this research. The administrator and the curriculum planner may integrate the model of meaningful mathematical learning in creating the course outline or syllabus in all mathematics subject. Parents may be guided in the use the model of meaningful learning in guiding their children in studying the mathematical concepts. Also, the students may use the model to understand better the math concepts.

- In response to the call of developing culture-fair assessment tools in the Philippines, it is highly recommended to establish a national norm for the meaningful mathematical learning experiences in order to expand its usefulness among college students regardless of age, gender, ethnic origin, socioeconomic status, and domicile.

8.Conclusion

The first dimension of meaningful mathematical learning experiences is the cooperative meaningful learning. In this dimension, communication with their schoolmates and tuning in to their colleague's clarification were the key purposes of understanding the numerical ideas. Understudy correspondence happened in little gatherings; this configuration enabled understudies to decipher ideas in understudy cordial dialect, along these lines profiting understudies who did not comprehend the instructor's clarification. Understudies tended to stay on an errand as they talked, as opposed to capitulating to the wandering off in a fantasy land that will probably occur amid calm eras. In the helpful learning, understudies cleared up their own reasoning as they talked **(Kagan, 2009).**

Improvement of social aptitudes was likewise analyzed by **Vaughan (2002)** on the impacts of helpful learning on the accomplishment and demeanors towards arithmetic of a gathering of fifth graders. The understudies took part in twelve-weeks in agreeable learning in mathematics. The discoveries proposed that there is a positive change in the state of mind and accomplishment. This finding affirms the significance of helpful learning in the aggregate improvement of the individual in learning mathematics. In addition**, Nichols (1996)** used cooperative learning strategies within Mathematics instruction. The findings suggested that there are numerous advantages to learners' growth that might influence them to become competent learners. Moreover, **Slavin (2014)** likewise found that understudies feel more achievement when working in gatherings and are more effective working with different sorts of understudies. Those understudies who pick up the most out of helpful gatherings are those understudies who will give and get. Additionally, **Yamarik (2007)** discovered three conceivable explanations why helpful learning bunches accomplished better on assessments. In the first place, helpful learning raised understudy teacher connection. Understudies felt happier with making inquiries as a gathering than exclusively. Second, agreeable learning expanded gathering considerations. Third, the curiosity of functioning in little gatherings started more prominent enthusiasm for the material.

Agreeable learning does not just help the understudy passed the subject and build up its social aptitudes. **Law (2011)** discovered the helpful learning stirs the enthusiasm of the understudies. Be that as it may, it accentuated that different agreeable learning systems ought to be fun and locks in. Educators were urged to adjust their helpful learning techniques to the kind of students that they are managing. More so, cooperative learning strategies are meaningful in mastering the mathematical concepts. Several researchers claim that when learners participate with cooperative learning, not only do their grades improve, but they also grasp the concepts better **(Hooker, 2011; Mevarech, 1985; Whicker, Bol, & Nunnery, 1997; Souvignier, & Kronenberger, 2007; Tarim, 2009; Pierce, Cassady, Adams, Speirs Neumeister, Dixon, & Cross, 2011)**. **Hooker (2011)**further cited that "results indicate that the collaborative learning groups did have a positive effect on the learning of mathematical concepts".

Numerous specialists including agreeable learning led to the wellbeing unified understudies. A few specialists have revealed valuable parts of agreeable adapting, for example, enhanced relational connections, confidence, and relational abilities) yet have not tended to the issue of understudy accomplishment **(Caprio, 1993; Drew, 1990)**. Five reports included exact (considering perception or experience) information for assessing understudy accomplishment. Two of these detailed no huge contrast in accomplishment between the agreeable learning gathering and the control gathering **(Posner & Markstein, 1994; Overlock, 1994)**. Every one of these examinations had a few impediments in their exploratory outlines.

In the third examination, the cooperative learning assembles revealed expanded accomplishment on tests given toward the finish of every one of two science research centers contrasted and the control gathering **(Smith, Hinckley & Volk, 1991)**. This distinction may have happened in light of the fact that cooperative learning lab areas were educated by the analyst while the control research facility segments were instructed by graduate associates. In the fourth investigation, **Frierson (1986)** revealed that nursing understudies who arranged for the national board examination by concentrate in groups did essentially superior to understudies who contemplated independently.

Another dimension meaningful mathematical learning experience is the real-life learning. The credible learning encounters are all around organized assignments, important to most understudies, and, maybe above all, they empower understudy heading. They include perceptions, examinations, critical thinking, tests, displaying, exhibitions, and imaginative elucidations. As did the Productive Pedagogies of the Queensland School Reform Longitudinal Study **(Ladwig, Lindgard, Mills, and Land, 2001),** they propose scholarly quality, involvement with the understudies' reality, a steady domain and acknowledgment of individual distinction. Valid learning encounters, as the word true means, contain procedures and methodologies that are engaged with typical life exercises. Accordingly, understudies ought to have data and assistance from specialists, access to instruments, and peers discussions, like issue solvers or entertainers in reality **(Wiggins, 1993).**

Callison and Lamb (2004) announced that in the region of the data request, legitimate learning happened at the convergence of working environment data issues, individual data needs, and scholarly data issues or undertakings. They distinguished these seven indications of real learning: understudy focused getting the hang of, getting to of various assets past the school, understudies as logical students, the chance to assemble unique information, long-lasting learning past the task, legitimate evaluation of process, item and execution, and group coordinated effort.

Real learning in arithmetic must happen through revelation, request, and acceptance. Conventional arithmetic issues displayed to understudies have only expected understudies to apply a known methodology, limiting the requirement for elucidation. Interestingly, genuine scientific undertakings give reasonable and complex numerical information, address an extensive variety of foundation learning and abilities, and frequently expect solvers to utilize distinctive portrayals in their answers **(Forman & Steen, 2000; National Council of Teachers of Mathematics(NCTM), 2000)**. Cases of such rich issues are show evoking issues **(Lesh, Hoover, Hole, Kelly, & Post, 2000)** that hold fast to the accompanying standards: individual seriousness to understudies; development, refinement, or augmentation of a model; self-assessment; documentation of numerical reasoning; valuable model for other basically comparative issues; and speculation to a more extensive scope of circumstances.

The last measurement of significant learning is the derivative subsumption and advance organizer. The two things cannot be separated from each other since the advance organizer will act as an instrument that connects with the previous and new concept. Ausubel's subsumption hypothesis depends on the possibility that a person's current psychological structure (association, dependability, and lucidity of information in a specific subject) is the primary and fundamental factor impacting the learning and maintenance of important new material. It depicts the significance of relating new plans to an understudy's current information base before the new material is introduced. This hypothesis is connected to the 'propel coordinator' technique created by Ausubel. From Ausubel's point of view, this is the significance of learning.

At the point when data is subsumed into the student's intellectual structure, it is sorted out progressively. New material can be subsumed in two diverse courses, and for both of these, no significant learning happens unless a stable intellectual structure exists. This current structure gives a system into which the new learning is connected, progressively, to the past data or ideas in the person's subjective structure. Ausubel, whose hypotheses are especially important for instructors, considered neo-behaviorist perspectives lacking. Even though he perceived different types of taking in, his work concentrated on verbal learning. He managed the idea of importance and trusts the outside world gets meaning just as it is changed over into the substance of awareness by the student.

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