Introduction of the Construction Decision Making Inventory (CDMI) to Improve Educational Experience

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Abstract
Each learner has different characteristics, learners are not a homogenous mass, but vary considerably in terms of educational background, income, age and learning experience. These differences affect how they make decision and perform as practicing professionals, educators and students in the Architecture, Engineering and Construction (AEC) industry. These decisions impact each individual project that collectively represents the construction industry which is one of the largest economic sectors of most localities, states and countries around the globe.

Although research has been done in decision making and some psychometric instruments exist in this area, there was no tool that allowed to measure the decision making process of the AEC practicing professional and students. Thus, the focus of this research paper is to introduce the Construction Decision Making Inventory (CDMI) that was recently developed by Dr. Tulio Sulbaran to fill this important gap in the AEC industry. The content of this paper is very important as it helps better understand practicing professionals, educators and student. This understanding of how students make decisions has the potential to allow educators to tailor their classes to target the specific decision-making dimensions of the students and therefore improving the educational experience and achievements of the students.

Keywords
Decision Making, Construction, Tool, Inventory, Educational Experience, Development

Introduction
The traditional 18 to 22 years old student is now the minority in higher education. According to the National Center for Education Statistics there are 17.6 million undergraduates. Thirty-eight percent of those enrolled in higher education are over the age of 25 and 25 percent are over the age of 30. The share of all students who are over age 25 is projected to increase another twenty-three percent by 2019. (Bell, S., 2012). Additionally, University budget cuts and tuition increases are forcing more traditional students to take jobs in addition to their study activities. These and many other factors are increasing the demand for more individualized learning (Schuwer & Kusters 2014). Each learner has different characteristics, learners are not a homogenous mass, but vary considerably in terms of educational background, income, age and learning experience. This diversity of the student body is growing fast (Bates, A. W. 2005). Thus, it is becoming increasingly important for universities to meet this growing demand.

Meeting the individualized learning demand, requires a blend of innovation and knowledge, particularly knowledge about the students. There is a plethora of personally test, career aptitude test, and learning styles assessment among others that could be used to better understand the individual learner needs. However, one of the most important assessment gaps is on decision

making. Decision making is particularly important in the construction industry where professionals are continuously making decisions that have different impact on the projects. Thus, the focus of this research paper is to describe the theoretical framework of the Construction Decision Making Inventory (CDMI) that could be used to better understand each student. This understanding of the student could help professors tailor the students' learning experience targeting the specific decision-making dimensions and therefore improving the educational experience and achievements of the students

CDMI Theoretical Framework

The development of the Construction Decision Making Inventory (CDMI) is an important step into determining the decision-making process of practicing professionals and students in the construction sector. Research on decision-making has been conducted by multiple disciplines. However, a construction decision making inventory did not exist until the CDMI was developed. Thus, the construction industry has been using personality profile assessment for multiple purposes such as: hiring employees, leadership development, team placement/development and/or position/promotions placement. Hiring employees is the primary purpose that the assessments have been used (Childs, B 2015). Universities have also used personality profile assessment to try to better understand the students. The personality profile assessments have been administered during: hiring process, employee reviews, promotions, and/or as needed. Regardless of the particular purpose or when the assessments are administered, a large majority strongly agreed that the results of personality profile assessments have been helpful (Childs, B 2015). A good percentage of construction companies that have not used personality profile assessments is because they do not know much about personality profile assessment. Therefore, the development of a tool specifically to measure construction decision making as the CDMI and its dissemination is very important for the construction education and industry.

The CDMI was recently developed by Dr. Tulio Sulbaran. The CMDI is grounded on three pillars: 1- Psychometric, 2- Science of decision making, and 3- Construction industry knowledge management and best practices (as shown in Figure 1).

1- Psychometrics: involves two major tasks: a- the construction of instruments; and b- the development of procedures for measurement. It is concerned with the theory and technique of psychological measurement. The construct of instruments focuses on the objective measurement of skills and knowledge, abilities, attitudes, personality traits, and educational achievement. The development of procedures for measurement focuses on the statistical research bearing on measurement theory. (Wikipedia 2016)
2- Decision Making: is one of the basic cognitive processes of human behaviors by which a preferred option or a course of actions is chosen from among a set of alternatives based on certain criteria (Wang and Ruhe 2007). Research of decision making is shared by many disciplines, from mathematics and statistics, through economics and political science, to sociology and psychology. The study of decisions addresses both normative and descriptive questions. The normative analysis is concerned with the nature of rationality and the logic of decision making. The descriptive analysis, in contrast, is concerned with people's beliefs and preferences as they are, not as they should be. (Kahneman, D., Tversky, A. 2000).

3- Construction industry knowledge management and best practices: are two interrelated critical concepts for the construction industry. Knowledge management refers to the creation of a thriving work and learning environment that fosters the continuous creation, aggregation, use and re-use of both organizational and personal knowledge in the pursuit of new business value. (Anumba, C. et al 2005). Best practices are defined as the policy, systems and procedures that, at any given time, are generally regarded by peers as the practice that delivers optimal outcome, such that they are worthy of adoption (The Constructor n.d).

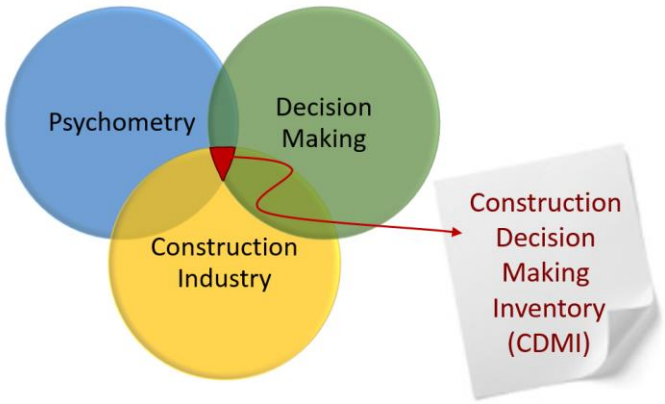

Figure 1. Vent diagram representation of the CDMI Pillars

In addition to the three pillars described above the following considerations survey design best practices were considered during the preparation of the CDMI:

1- Questionnaire length: is a function of three components: 1- the length of individual questions, 2- the number of questions, and 2- the format of questions included in the survey. Literature documents that there is a relationship between questionnaire length and data accuracy (Iarossi, G. 2006). A good rule of thumb is to never go over 15 minutes for a general public survey to reduce the possibility of decreased response rate (FluidSurveys n.d.).

2- Questionnaire layout: relates to the principles to ensure that the questionnaire is convenient for the participants, as well as easy to identify, code, and store. This principle include the proper use of: identification, numbering, space, instructions, fonts, formats and symbols. (Larossi, G. 2006).

3- Questions' order: corresponds to the sequence in which the questions and answers are presented to the participants. This sequence could influence their answers. (Harrison, C. 2007). The following four main things need to be considered: 1- *Primacy effect* is the participants tendency to pick the first choice, 2- *Recency effect* is the participants tend to pick the choice that they heard most recently (when questions are read to participants), 3- *Randomization* is usually a good idea, and 4- *Radio button* work better than drop-down menus (for internet survey).

4- Questions' goals: should focus on accomplishing the following: 1- Measure the underlying concept; 2-Not measure other concepts, and 3- Mean the same thing to all respondents. (Harrison, C. 2007).

5- Questions' wording: refers to the phrasing used to elicit information from the participants. Once the research has decided which questions to use in measuring each variable, the specific wording of each question must be worked out (Weisberg, H. et al1996). Because of the unique needs of each question, there is no universally accepted theory on question wording (Harrison, C. 2007). The following four criteria should be considering when wording an question: 1-Brief, 2-Objective, 3-Simple,and 4- Specific (or BOSS)
6- Questions' type: are mainly unstructured/open-ended and structured/close-ended (Trochim, W. 2006). Open-ended questions ask participants to respond to a question in their own terms. Closed-ended questions provide the participants a limited number of responses
7- Rating Ordinal scales: provides the participants responses in close-ended question that vary from two extremes. The following four main elements should be considered: 1- Five to seven points is usually best, 2- Middle category provides better data, 3- Label clearly the points on the scale, and 4- Both extremes of the scale should have s "high" and "low scores.

Description of the CDMI

The state-of-the-art in 1- Psychometric, 2- Science of decision making, and 3- Construction industry knowledge management and best practices in conjunction with best practices of survey design were used by Dr. Tulio Sulbaran to develop the Construction Decision Making Inventory (CDMI). The CDMI is in the early stages of development and it is the first attempt to measure the What? When? How? Who? and Why? of the construction decision making process. The CDMI tool is composed of 52 closed-end questions plus 20 closed-end questions from the rational-experiential inventory (that will be used in the reliability and validity evaluations). The closed-end questions use a 5 choice Likert scale ranging from completely false to completely true. The participants select one of the choices in each of the questions. All of the CDMI questions take less than 15 minutes for the participants to complete/answer.

The participant answers are used to calculate the five dimensions determined by the CDMI (What? When? How? Who? and why?). Each of the five dimensions is appraised on a uniaxial scale. The uniaxial scale has two diametrical opposite poles allowing to assess a participant within the range of the poles. The following is a description of the five dimensions:

1- What?: examines the perceived outcome of the decision making process. In other words, focuses on the "Results" and its spectrum of possible results in the uniaxial scale is from inadequate to satisfactory as shown in Figure 2. The inadequate end of the spectrum indicates that the results of the decision-making process are either lacking the quality, quantity or sufficiency. The satisfactory end of the spectrum represents that the results of the decision-making process are acceptable and fulfil the expectations and/or needs.

Figure 2 – CDMI's What? - Dimension from Inadequate to Satisfactory

2- When?: Focuses on the amount of time taken to make decision. In other words, focuses on the "Timeframe" and its spectrum of possible results in the uniaxial scale is from deliberate to swiftly as shown in Figure 3. The deliberate end of the spectrum denotes that the decision maker engages in detailed and careful considerations before making the decision. Swiftly end of the spectrum signifies that the decisions are made promptly without delaying them.

Figure 3 – CDMI's When? Dimension from Deliberate to Swiftly

3- How?: Appraises the approach followed to make decisions. In other words, focuses on the "Method" and its spectrum of possible results in the uniaxial scale is from intuitive/judgmental to rational/systematic as shown in Figure 4. The intuitive/judgmental end of the spectrum corresponds to decision reached on the basic of subjective feelings on basis that cannot be articulated easily and not fully conscious. The systematic end of the spectrum corresponds to a decision-making process that is reached by a step by step method applied to (quantitative or qualitative) data obtained through observation, mathematical analysis, and/or modeling.

Figure 4 – CDMI's How? Dimension from Intuitive/Judgmental to Rational/Systematic

4- Who?: Looks in to the influence and/or reliance of decision maker in other people. In other words, focuses on the "Involvement" and its spectrum of possible results in the uniaxial scale is from individual to group (consensus/consultation) as shown in Figure 5. The individual end of the spectrum corresponds to decision making done without the input of other people. The group end of the spectrum corresponds to decision making considering the opinion of other people.

Figure 5 – CDMI's Who? Dimension from individual to group (consensus/consultation)

5- Why?: Investigate the purpose and/or motivation to make decisions. In other words, focuses on the "Reason" and its spectrum of possible results in the uniaxial scale is from survival to self-actualization as shown in Figure 6. The survival end of the spectrum indicates that the individual physical needs have not been completely met yet during the decision-making process. The self-actualization end of the spectrum suggest that all needs have been met and the person is striving to server others for the greater good.

Figure 6 – CDMI's Why? Dimension from survival to self-actualization

The calculations of the five dimensions determined by the CDMI (What? When? How? Who? and why?) have the following possible outcomes

1- What? – Results (8 questions): Participants that consider (based on their answers) that the majority of their decisions' result are satisfactory receive the "SA" designation. Likewise, the participants that consider that the majority of their decisions' result are inadequate receive an "IN" designation. Those participants that consider that approximately equal number of decision's results are either inadequate and/or satisfactory receive an "IS" designation as shown in figure 7.

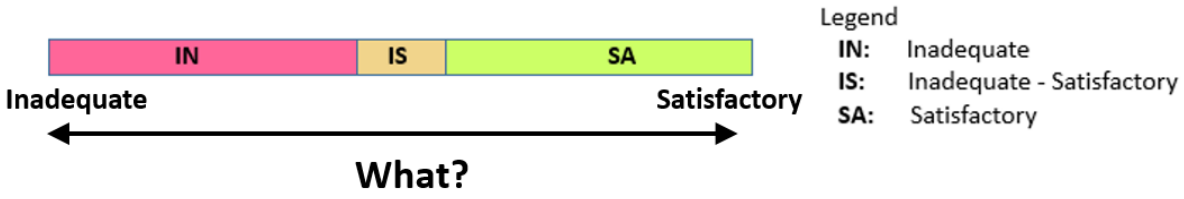

Figure 7 – What? - Results Dimensions' Designation

2- When? – Timeframe (8 questions): Participants that consider (based on their answers) that they have detailed and careful considerations before making the majority of their decisions receive the "DE" designation. Likewise, the participants that consider that they make decisions without delaying them receive an "SW" designation. Those participants that consider that approximately equal number of decision's are done deliberate and/or swiftly receive a "DS" designation as shown in figure 8.

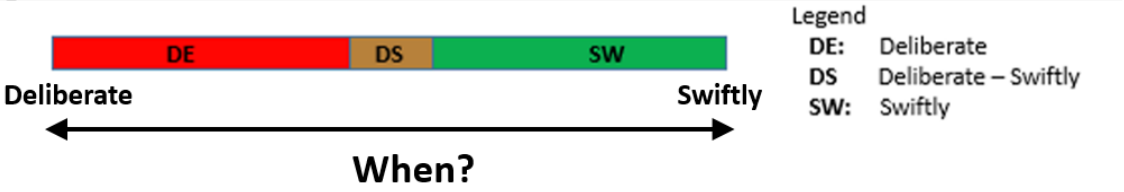

Figure 8 – When? - Timeframe Dimensions' Designation

3- How? – Method (8 questions): Based on the participant's answers to the questions, the CDMI calculates the prefer method of the participant to make decisions. If the participant has a stronger tendency to use subjective feelings, the participant receive an "IJ" designation. If the participant has stronger tendency to use a step by step method, the participant receive a "RS" designation. Those participants that have a tendency to use both method approximately equally receive a designation "IR" as shown in figure 9.

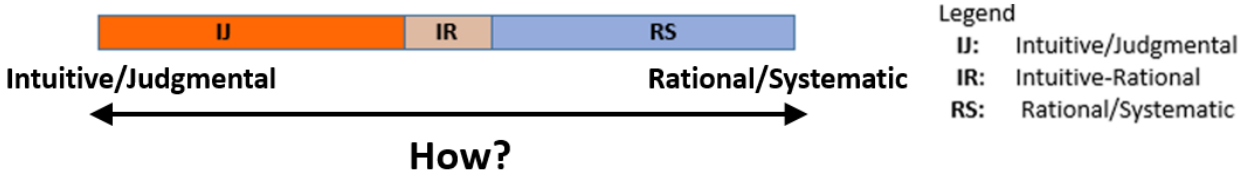

Figure 9 – How? - Method Dimensions' Designation

4- Who? – Involvement (8 questions): The participant's answers to the questions are used by the CDMI to calculate the involvement of other people in his/her decision making process If the participant mainly make decisions without the input from other receive an "IN" designation. If the participant relies on other people to make decisions, the participant receive a "GR" designation. Those participants that equally make decision without input from others and relies on others to make decisions receive a designation "IG" as shown in figure 10.

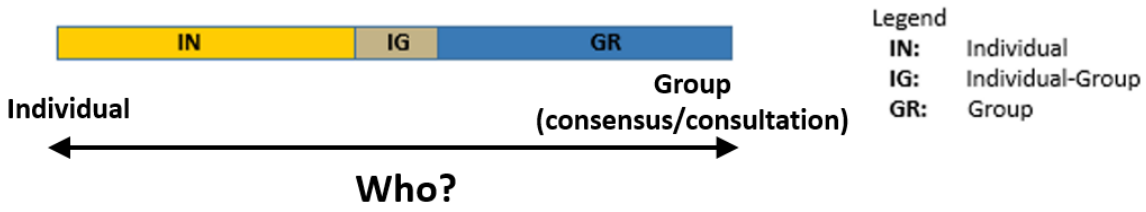

Figure 10 – Who? - Involvement Dimensions' Designation

1- Why? – Reason (20 questions): The answers from the participants are used by the CDMI to determine the individual needs based on the Maslow's hierarchy of needs. If the participant mainly make decisions to full-fill survival needs a "SU" designation is assigned. If the participant mainly make decision for security, the participant receive a "SE" designation. If the participant mainly make decision to belong, the participant receive a "BE" designation. If the participant mainly make decision for importance, the participant receive a "IM" designation and those participate that make decision mainly for self-actualization receive a "SA" designation as shown in figure 10.

Figure 11 – Why? – Reason Dimensions' Designation

CDMI to Improve Educational Experience

The five decision-making dimensions determined by the CDMI (what? when? how? who? and why?) can be used by the professor individually or combined to tailor lectures, activities, and assessment to meet individual learning needs. The following are some examples on how to use the results of CDMI:

1- What? – Results: If the perceived performance of the students do not match the reality of the performance in a class. The professor could add as a final question to the exams asking the students to write down an honest estimate of the percentage of questions they believe they got right, from 0 to 100%. After grading the exam, the professor could prepare a scatterplot of the students estimated scores against their actual scores. Students with good metacognition of their performance should fall close to the diagonal, but probably the entire class will show an overestimate of their performance. It is also likely that this overestimate will be larger for students with lower scores. The point is not to embarrass students with the poor performance, but to make them aware of the problem so they can make appropriate adjustments to improve performance. Many factors impact Students' performance. Students' performance improvement takes time and effort from all parties involved. One of the multiple methods to improve performance is practice exercises (graded or non-graded). Professors could develop a series of exercises ranging from well-defined problems will all data provided to students to ill-defined problems with multiple assumptions to be made by the students. The students would need to complete the easier exercises first to be

granted the opportunity to continue to the most challenging exercises. In the most challenging exercises students will be expected to make assumptions. The assumptions made by the students should be well documented and grounded. This process should help the students learn the fundamentals prior to moving to more complex/ill-defined problems. It is alos important to stress to the students that well-defined problems with all information easily accessible are more the exemption than the rule in most professional fields particularly in construction.

2- When? – Timeframe: There is a correlation between speed and accuracy (correctness) of a decision. While there are exceptions to the rule, experience has taught that decisions made quickly don't work out as well as decisions made after taking the proper time to evaluate options thoroughly. The evaluation is normally done through an individual process. If a student has an inefficient or non-existent process to ensure the accuracy of a decision, the speed of the decision suffers (AMA, 2017). Thus, the professor could develop exercises that require the student to make decision. The decision-making process could be framed by a series of parameter and the parameter could be increased in number of complexity with each exercise.

3- How? – Method: Decision techniques in the construction industry could be grouped in Heuristics, Mathematical Modeling and Artificial Intelligence (as shown in Figure 12). The first two groups should be the focus of the professors in construction. Discussion centered around knowledge needed to make heuristics decisions could be an activity that the professor include into the class. Additional, the professor could prepare assessments that requires the students to follow a step by step procedures.

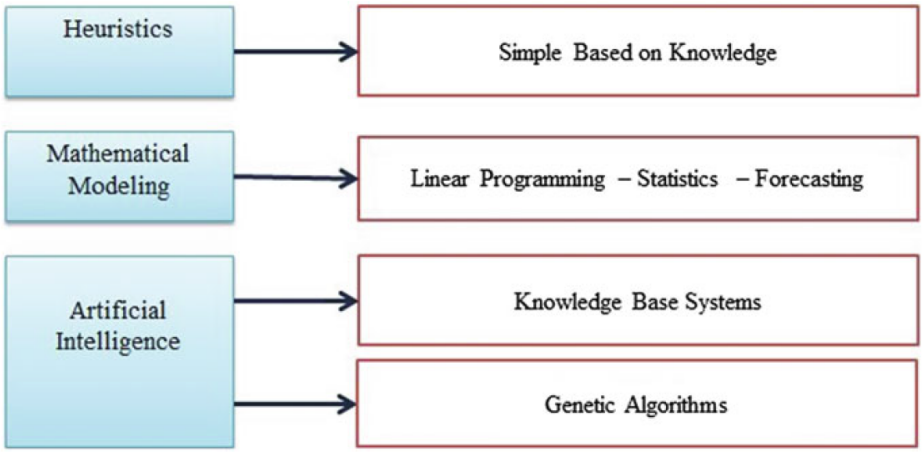

Figure 13 – Decision-making techniques in construction (From: Ali D. Haidar,2016).

4- Who? – Involvement: effective decisions require clear thinking about information, commitment and potential conflict of the people involved. That means clear thinking requires careful consideration about who should be involved in making the decision. Involving the right people can be the difference between a good decision and a bad one that results in ambiguity and inconsistency (Kepner Tregoe. (2017). The professors could create a hypothetical situation and have an in-class debate requiring the students to analyzed the situation and discuss the possible scenarios using the five question below as guidance. Particular emphasis should be put into who should be involved in the decision-making process.

Table 1 – Question to Guide the Involvement of people in a decision

Question for Involvement
How important is the decision?
How much do we know about the decision?
How much support do we need?
How well aligned are people's goals?
How much conflict is there about the decision?

5- Why? – Reason: Whether student realize it or not, people make decisions everyday, both big and small. Life is constantly throwing different scenarios and forcing students to make decisions based on that given situation (Bryan, 2012). Students make decisions based on whether the results will benefit them or not. If there are two alternatives both beneficial, students will choose the alternative that is more beneficial and those benefits are based on priority. Thus, if the student priority is survival (i.e Pass the class) most the decisions will be based on that need. Thus, the faculty could establish prepare a series of bonus that due in the middle of the semester, before all grades are available. This will put the students in the position to make the decision to complete the bonus or not without knowing all the facts but driven by their own priorities.

Additionally, the professor could establish correlations between each student performance and the five decision-making dimensions determined by the CDMI (what? when? how? who? and why?) either individually and/or any combination. The professor could use this correlation between performance and decision-making dimension to forecast possible student performance and to implement early intervention to assist the students to better understand a topic before their grade has suffered or the knowledge is needed to better under more advanced knowledge. Furthermore, the professor could prepare individual decision-making profiles using the template show in table 2 for the students to visualize their decision-making characteristics.

Table 2 – CDMI Dimensions and Designations

CDMI Dimension	Designations				
What? – Results	**IN** Inadequate		**IS** Inadequate-Satisfactory		**SA** Satisfactory
When? – Timeframe	**DE** Deliberate		**DS** Deliberate – Swiftly		**SW** Swiftly
How? – Method	**IJ** Intuitive/Judgmental		**IR** Intuitive-Rational		**RS** Rational/Systematic
Who? – Involvement	**IN** Individual		**IG** Individual Group		**GR** Group
Why? – Reason	**SU** Survival	**SE** Security	**BE** Belonging	**IM** Importance	**SA** Self-Actualization

Summary

Practicing professionals, educators and students in Architecture, Engineering and Construction (AEC) industry are continuously presented with situations where they have to make decisions. This research paper described the theoretical framework of the Construction Decision Making Inventory (CDMI). The theoretical framework described in this paper is very important as it helps understand how practicing professionals, educators and students make decisions. This understanding of how students make decisions has the potential to allow educators to tailor their classes to target the specific decision-making dimensions of the students and therefore improving the educational experience and achievements of the students.

This paper describes the five dimensions measured by the CDMI: 1- What? – Results; 2- When? – Timeframe; 3- How? – Method; 4- Who? – Involvement; and 5- Why? – Reason. For each of the five dimensions; specific classroom activities were described to tailor the learning activity to the students and to help improve individual performance. Additional, correlations between the CDMI dimensions and the students' performance in a subject manner could be used to forecast future performance and implement early interventions.

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