Ain Shams Engineering Journal xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Ain Shams Engineering Journal

journal homepage: www.sciencedirect.com

Quantifying students' perception for deconstruction architecture

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ARTICLE INFO

Article history:
Received 8 May 2017
Revised 23 September 2017
Accepted 27 September 2017
Available online xxxx

Keywords:
Deconstruction
Derrida
Perception
Architecture
Creativity

ABSTRACT

Deconstruction in architecture is like a symbol of liberty. The French philosopher Jacques Derrida started the idea basically in language, and then his idea spread to reach architecture. Deconstruction move produced unique differentiated buildings, where difference was the main idea behind deconstruction. This actually made a deep debate, whether deconstruction was an out of the box philosophy or just a strange architectural composition. The research addressed that this kind of architecture needs complete architectural education to value the philosophy behind it, in addition to highlight how students of architecture in both (juniors level and seniors level), how they perceive deconstruction; an experimental approach was used to find out if the scientific material given in architectural theories about deconstruction may affect the perception levels of the students, these students joined the architectural program at faculty of engineering, Zagazig University, Egypt, and the experiment applied on selected pioneers of deconstruction famous buildings.

First: Literature Approach

1. The beginning of deconstruction

Philosopher Jacques Derrida came up with deconstructionism as means to reveal any hidden layers of something. It started in text or language for educational reasons, then it moved to architecture. Derrida cooperated with many philosophical thinkers to formulate his own philosophy on deconstruction [1]. His point of view was that any receiver should interact with the product – be it text or buildings – and read it critically so he can reveal its aspects. He clarified that it was an interactive relation within a critical thinking context [2]. Derrida aimed to work on various audiences as means of communicating with the critical readers of his philosophy, so that receivers could formulate their own experiences in relation to what kind of critical readers they were. Based on that, he defined deconstruction as a strategy of architectural analysis [3].

Time connects deconstruction with perception; where perception increased with the time spent to understand and perceive the meaning behind the architectural product. Deconstruction breaks boredom and the silence of composition if compared to modernism. However, deconstruction may propose structural problems with respect to the stability of buildings, although it doesn't lead them to collapse. It represents a new challenge to stability by confirming structural performance and showing the capabilities of construction materials [4].

2. Deconstruction philosophy

Two aspects generally govern the perception of buildings; the first is a denotative aspect which relates to cognition, as buildings can be recognized for their usage, such as a school or a hospital, through its form. Recognition gets harder when it deals with deconstruction, as it already calls for freedom from cognition. The second aspect in buildings perception is a connotative one, referring to the emotional perception; such as likeness of buildings [5]. Deconstruction mostly features dynamic buildings, which gain their design concepts from motion, while they are not actually moving, but when a building has more than one form when seen through different angles [6], it seems as if it is moving.

According to the American architect Peter Eisenman, there are two kinds of forms: generic and specific. Both combine different paradigms of form, but they both represent transformed primary

Peer review under responsibility of Ain Shams University.

ELSEVIER Production and hosting by Elsevier

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https://doi.org/10.1016/j.asej.2017.09.006
2090-4479/

Please cite this article in press as: Hegzi YS, Abdel-Fatah NA. Quantifying students' perception for deconstruction architecture. Ain Shams Eng J (2017), https://doi.org/10.1016/j.asej.2017.09.006

solids [7]. Eisenman assumed that a building can also be read as a sentence according to its perceived meaning! [8].

Derrida outlined by his philosophy that creativity is represented through the adaptation of a product with its context [9]. Accordingly, deconstruction was perceived to be a re-reading in architectural theories that is based on questioning, below a critical thinking umbrella. Derrida's definition of deconstruction mostly focuses on a reversal of classic architecture being criticized by questioning, a procedure that can be considered a prerequisite of deconstruction itself. A collaboration between Eisenman and Derrida produced the item of Chora which can be defined as a difference or a trace of meaning that shapes a content without having its common physical form. In this way, Chora represented an analysis mode [10] that guided Eisenman in his designed deconstruction products.

3. Deconstruction in architecture

The idea of deconstruction came to reality thanks to the American Canadian architect Frank O. Gehry, Gehry bought a house in Santa Monica in a district mostly had a classic design for its houses, he made major changes without removing the original decoration or even change the house style, he just surrounded the original exterior with new layers of linear spaces all around the old, he used materials criticized heavily then by saying that it's a railways industrial materials, the old exterior was seen behind the glass of the new added exterior, at that time it was said that no one liked this house except Frank Gehry himself, even most of the neighbors hated it, they never imagined then that they leave beside a new birth of an architectural trend

Many trials were done after Gehry trial to reach the idea of deconstruction. In 1985, Bernard Tschumi (http://www.tschumi.com) [11] invited Derrida to fill the missing gab in applying deconstruction to architecture. He started to write his vision about architecture and had it published in 1987. Then, Derrida joined Peter Eisenman in designing a certain section of La Villette project which represented deconstruction theories. Mark Wigley came up with an interpretation of deconstruction as a strange condition of structures using the primary necessary elements needed to let the building stand. He said it was a breakdown of necessary structural elements which were being concealed to express the required architecture elements instead [12].

To define deconstruction between architects' various theories, two events were held. The first was a one-day symposium in London in April 1988, and the second was an exhibition held at the Museum of Modern Art in New York, a few months later. The exhibition was organized by Charles Jenkns, who invited seven architects who were considered the deconstruction pioneers, in order to exhibit their work there. These architects were: Frank Gehry, Daniel Libeskind, Rem Koolhass, Peter Eisenman, Zaha Hadid, Coop Himmelblem and Tschumi. The architects proved that deconstruction buildings could produce beautiful products [13]. According to Mark Wigley and Philip Johnson, deconstruction was related to Russian constructivism; the movement which had appeared at the beginning of the 20th century which freed masses from their singular forms into becoming groups of disassembled masses [14].

4. What is perception?

Throughout history, many architects and urban planners thought much about how their buildings and urban settings were being perceived. This made them use philosophy as a tool to deliver their message. In the Gestalt laws of perception, one can recognize redundancy through the laws of similarity, while in the laws of proximity; elements are classified into groups. On the other hand, the laws of continuity and simplicity explained perception according to the arrangement of forms in the visual appearance; which related to both the information perceived and the redundancy in form [5]. For example, the surface of a building could be perceived as continuous according to the treatment applied to that surface. Another example is how buildings with flat facades and repeated windows, those that create a pattern, are less complex than the buildings that have an irregular form with less repetitive patterns [5].

The law of closure can be used as a perception tool as well, enabling an understanding of incomplete forms. In general, the laws of perception have mostly focused on how forms being perceived in 2D, so it will be very important to know if these laws can be applied to 3D forms; the research will clarify this point here through deconstruction architecture.

Between simplicity and complexity, deconstruction architects mostly design their buildings with varied complex forms that are based on primary solids such as cubes and parallel rectangles; which are used in their original proportions or transformed in dimension [15]. Perception in these buildings is reduced or raised according to the level of complexity, as these buildings could be perceived by visually disassembling them to simpler parts [5]. A form generally varies in being curved or rectangular, what direction it's oriented towards, whether it has parallel planes or angled ones, and also in terms of the kind of dimensional transformation and surface treatment applied to it. Perception got complicated when the basic boundaries of form were skipped in the process of complexity, as it's always important to recognize entrances, staircases and so on. This required clearance may actually be lost in form dynamics [5].

Perception in architectural forms requires perceiving the whole form before going into details. In perceiving architectural forms, the Gestalt theories featured two elements; the first being how the building deals with gravitation, while the second is how the structure appears. When those two elements are unconsidered, people get involved in trying to understand the building, thus perception gets complicated. This is why deconstruction was criticized by many architects, due to the irregularity of forms; despite the fact that many pioneer architects used irregularity of form, as applied in the celebrated Sydney Opera House and The Chapel of Notre dam du Haut in Ronchamp [16].

Perception starts with the first impression, then the whole building takes one's attention; eventually reaching a level of cognitive processing of perception. Perception is divided into two phases; the first is gathering information; represented by visual perception and the second is processing this information; which is called cognition; represented by both visual and mental. Here, it is worth to be mentioned that the visual perception is embedded into the mental perception. Visual perception starts with the overall physical appearance of the building, then it goes to building's mass. In this research, the mental perception is measured through the eight dimensions will be explained later in this research, as these dimensions depend on understanding the building's drawings, mass, photos, maps and other materials.

5. Deconstruction: Creativity aspects and perception

In architecture, creativity can be achieved through aspects of cost, safety, stability, or function, but it will be more realistic if creativity defined as something novel and appropriate created by producing the unexpected. This is how deconstruction took its position in the architectural creativity timeline [17]. Deconstruction is dealing with things by dividing them into their primary parts, where these parts can formulate a whole new form that reveals a difference in building structure to reach the intended

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design [18]. This is done within complete freedom of the usual design constrains such as function, utility, and aesthetics. Here, the designer rewrites a new meaning through these parts, and the perceiving audience tries to read it. The act of dividing produces incomplete geometrical forms, which are unstable, irregular, and unrecognizable; but all together reflect dynamism that is applied to all used parts. Through this method, deconstruction overcomes the perception of the common forms and frees the mind from the usual appearances, while reflecting a meaning in architecture. This meaning is expressed through lines, layers, planes, and sharp angles with no centralism to prevent the perceiving audiences from resolving to the use of the usual references in understanding the meanings of buildings, while setting them free to understand the meaning through critical thinking.

Deconstruction is considered a leaping step in architectural creativity; it leaves a great effect on the perceiving audience which exerts effort in critical thinking. Generally, when the gap between the architect's idea and the visitor's perception is reduced, this means that the architect has successfully delivered his message. This is the case in many types of architecture, but in deconstruction it gets so hard. In Aly Raafat 's [19] book, ''Aesthetic Creativity in Architecture", he assumed that there was an arrangement in perceiving architecture by arranging what to be perceived in order of what would naturally be seen first, the paper reaches to that unity and continuity had been seen first, then repose and scale, afterwards rhythm and proportions are given a deep look, then the receiver mentally starts to outline the creative effort of the architectural product, reaching the concept and formulating his final image of perception. This research depends on Professor Raafat's eight dimensions on perceiving an architectural products so it can be applicable on deconstruction as trend of architecture, he mostly formulated these dimensions from previous theorists discussed them, as Vitruvius, John Ruskin, Robert Venturi and others as explained in his book notes [20], these dimensions are the tools which are used in this research to measure the students perceptions of deconstruction buildings. Perception was outlined through a questionnaire; which was used to measure ''Students' Perception of Creativity in Deconstruction Architecture", which will be referred to in this research as the (PCDA) questionnaire.

6. Research objectives

This research aims at ***exploring students' perception of deconstruction architecture and how perception is affected by the ways architectural theories are being taught to them***. This breaks down into the following objectives:

- Realizing students' perception of deconstruction architecture in relevance to the seven pioneers.
- Creating an index of perception, which is a composite index generated from several indicators. It is used to measure the students' perception and rank them in relation to each other on the one hand and to the architects on the other. This perception index was built from the different dimensions of perceiving architecture which are unity and continuity, repose, scale, rhythm representation, proportion, creative efforts, truth, and image; all of which are explained later through this paper. The index was implemented on two stages, first: an indicator was built for every dimension, and second: a composite index was formulated from the eight indicators combined.
- Testing the differences between juniors' and seniors' perception of deconstruction architecture

Second: Methodology – Experimental Approach – Materials and Tools

7. Measuring students' creativity perception in deconstruction architecture

This part of the research highlights the experiment which was applied to juniors and seniors architecture students to measure their perception to deconstruction architecture buildings as follows:

7.1. Target students

Architectural studies in Egypt are either a 5-year duration in faculties of fine arts, or a 4-year duration in faculties of engineering where it's preceded by an introductory year to engineering disciplines in general. This research is done at The Faculty of Engineering, Zagazig University, Egypt; which features 4 years of architectural studies. The first perception of architecture for students comes from studying the ''History of Architecture" course, theory of architecture which mostly focuses on architects role and environment, as well as a fraction of perception achieved through the end of ''Design Studio 1" course which gives an introductory background and is presented in further advanced levels through the remaining 3 years. Further details on architecture get introduced in the second and third years through ''Theories of Architecture" and ''Philosophy of Architectural form and composition" courses. In the last year, more details are added through another ''Theories of architecture" course and ''Design Studio 4". So first year in architecture education consider lowest and fourth year highest level of studying architecture, respectively; a comparative analysis between two groups of students at the first and fourth years of architectural studies was held.

For students to be eligible to participate in this ''Perception of Deconstruction Architecture Survey", they had to be students of The Department of Architecture at The Faculty of Engineering, Zagazig University, and in the 1st or 4th years of architectural study. Due to the small number of students, it was suitable to create this statistical analysis with all the students of both years. The researcher selected the students of the 1st year, the ''juniors", and those of the 4th year, the ''seniors", in order to test the major assumption in this research which is ''how much the perception of the philosophy of deconstruction is affected by the scientific content learned by students during their academic years of study".

7.2. Featured projects

The criteria for selecting case studies, depends on the New York exhibition 1988 which revealed that deconstruction architecture will be the new trend in architecture, this exhibition was organized by Charles Jenkns at the Museum of Modern Art (MoMa), Jenkns introduced seven architects works in this exhibition, the criteria depends on that choice in selecting these architects for this research cases of study, the architects which named as the pioneers of deconstruction are: Bernard Tschumi, Coop Himmelblem, Daniel Libeskind, Frank Gehry, Peter Eisenman, Rem Koolhaas and Zaha Hadid, the buildings selected from these pioneers works, as the students were asked to search the most famous buildings for the selected architects and the buildings which were studied in this research came as a result of their research.

Deconstruction attracting architectural students by its boldness. To evaluate the level of perception of architectural students, many buildings were selected representing the pioneers' points of view in deconstruction. 93 buildings were chosen then arranged according to the alphabetical order of the architects' first names, as follows:

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7.2.1. First Pioneer: Bernard Tschumi

Building No. 87, 1998, Parc de la Villette, Paris. Building No. 88, 2004, Paul L. Cejas School of architecture, Florida International University, Miami, Florida. Building No. 89, 2004, Vacheron Constantin Headquarters, Geneva, Switzerland. Building No. 90, 2006, Lindner Center, University of Cincinnati. Building No. 91, 2007, Blue Condominium, 105 Norfolk Street, New York City. Building No. 92, 2007, Limoges Concert Hall, France. Building No. 93, 2008, New Acropolis Museum, Athens.

7.2.2. Second Pioneer: Coop Himmelblem

Building No. 1, 1994, Groninger Museum, Netherlands. Building No. 2, 1998, UFA-Cinema Center, Dresden, Germany. Building No. 3, 2001, The Gasometer, Vienna, Austria. Building No. 4, 2002, Arteplage Biel, Switzerland. Building No. 5, 2005, Academy of Fine Arts, Munich. Building No. 6, 2007, Akron Art Museum, Ohio, United States. Building No. 7, 2007, BMW World, Munich, Germany. Building No. 8, 2008, Central Los Angeles Area High School. Building No. 9, Museum des Confluences, France.

7.2.3. Third Pioneer: Daniel Libeskind

Building No. 74, 1998, Felix Nussbaum Haus, Osnabrück, Germany. Building No. 75, 1999, Jewish Museum, Berlin. Building No. 76, 2001, Imperial War Museum, Manchester. Building No. 77, 2003, Studio Weil, Mallorca, Spain. Building No. 78, 2003, Danish Jewish Museum, Copenhagen. Building No. 79, 2004, London Metropolitan University Graduate Center. Building No. 80, 2005, The Wohl Center, Bar-Ilan University, Ramat-Gan, Israel. Building No. 81, 2006, Denver Art Museum Residences, Colorado. Building No. 82, 2007, Michael Lee-Chin Crystal, Royal Ontario Museum, Toronto. Building No. 83, 2008, The Ascent at Roebling's Bridge, residential condominium, Covington, Kentucky, United States. Building No. 84, 2008, Westside Shopping and Leisure Center – Bern, Switzerland. Building No. 85, 2008, Contemporary Jewish Museum, San Francisco, California, United States. Building No. 86, 2010, Grand Canal Square Theatre and Commercial Development, Dublin, Ireland.

7.2.4. Fourth Pioneer: Frank Gehry

Building No. 18, 1978, Gehry Residence, Santa Monica, United States. Building No. 19, 1989, Vitra Design Museum, Weil am Rhein, Germany. Building No. 20, 1991, Chiat/Day Building, Venice, California. Building No. 21, 1993, Frederick Weisman Museum of Art, University of Minnesota, Minneapolis, Minnesota. Building No. 22, 1995, Fred and Ginger (currently Dancing House), Prague, Czech Republic. Building No. 23, 1997, Guggenheim Museum Bilbao, Bilbao, Spain. Building No. 24, 1999, Der Neue Zollhof, Düsseldorf, Germany. Building No. 25, 2000, DZ Bank Building, Berlin, Germany. Building No. 26, 2000, Experience Music Project Museum, Seattle, Washington. Building No. 27, 2001, Gehry Tower, Hanover, Germany. Building No. 28, 2001, Issey Miyake Flagship Store, New York. Building No. 29, 2003, Richard B. Fisher Center for the Performing Arts, Bard College, Annandale-On-Hudson, New York. Building No. 30, 2002, Peter B. Lewis Building, The Weatherhead School of Management, Cleveland. Building No. 31, 2003, Maggie's Dundee, Ninewells Hospital, Dundee, Scotland. Building No. 32, 2003, Walt Disney Concert Hall, Los Angeles, California. Building No. 33, 2004, Ray and Maria Stata Center, Massachusetts Institute of Technology, Cambridge, Massachusetts. Building No. 34, 2004, Jay Pritzker Pavilion, Millennium Park, Chicago, Illinois. Building No. 35, 2006, Marqués de Riscal Vineyard Hotel, Elciego, Spain. Building No. 36, 2007, IAC/InterActiveCorp Headquarters, New York. Building No. 37, 2008, Peter B. Lewis Library, Princeton University. Building No. 38, 2008, Serpentine Gallery Pavilion, London, England. Building No. 39, 2010, Lou Ruvo Center for Brain Health, Las Vegas, Nevada.

7.2.5. Fifth Pioneer: Peter Eisenman

Building No. 10, 1989, Wexner Center for the Arts, Ohio State University, Columbus, Ohio. Building No. 11, 1991, Nunotani Corporation Headquarters Building, Edogawa, Tokyo, Japan. Building No. 12, 1993, Greater Columbus Convention Center, Columbus, Ohio. Building No. 13, 1996, Aronoff Center for Design and Art, University of Cincinnati, Cincinnati, Ohio. Building No. 14, 1999, City of Culture of Galicia, Santiago de Compostela, Spain. Building No. 15, 2004, Il Giardino dei passi perduti, Castelvecchio Museum, Verona, Italy. Building No. 16, 2005, memorial to the Murdered Jews of Europe, Berlin. Building No. 17, 2006, University of Phoenix Stadium, Glendale, Arizona.

7.2.6. Sixth Pioneer: Rem Koolhass

Building No. 61, 1988, Lille Grand Palais, Lille, France. Building No. 62, 1991, Villa dall'Ava, Saint-Cloud, Paris. Building No. 63, 1993, Kunsthal Rotterdam, Rotterdam, Netherlands. Building No. 64, 1998, Maison a Bordeaux, Bordeaux, France. Building No. 65, 1999, Second Stage Theatre, New York City. Building No. 66, 2003, McCormick Tribune Campus Center, Illinois Institute of Technology, Chicago. Building No. 67, 2003, Embassy of the Netherlands in Berlin, Germany. Building No. 68, 2004, Seattle Central Library, Seattle. Building No. 69, 2005, Casa da Música, Porto, Portugal. Building No. 70, 2006, Serpentine Gallery Pavilion, London. Building No. 71, 2009, Dee and Charles Wyly Theatre, Dallas, Texas. Building No. 72, 2009, CCTV Headquarters, Beijing. Building No. 73, 2010, Torre Bicentenario (Bicentennial Tower), Mexico City, Mexico.

7.2.7. Seventh Pioneer: Zaha Hadid

Building No. 40, 1994, Vitra Fire Station, Weil am Rhein, Germany. Building No. 41, 2002, Bergisel Ski Jump, Innsbruck, Austria. Building No. 42, 2003, Rosenthal Center for Contemporary Art, Cincinnati, Ohio. Building No. 43, 2005, BMW Central Building, Leipzig, Germany. Building No. 44, 2005, Ordrupgaard Annexe, Copenhagen, Denmark. Building No. 45, 2005, Phaeno Science Center, Wolfsburg, Germany. Building No. 46, 2006, Maggie's Fife, Victoria Hospital, Kirkcaldy, Scotland. Building No. 47, 2006, Tondonia Winery Pavilion, Haro, Spain. Building No. 48, 2007, Hungerburgbahn Railway Stations, Innsbruck, Austria. Building No. 49, 2008, Chanel Mobile Art Pavilion, Tokyo/Hong Kong/New York/London/Paris/Moscow. Building No. 50, 2008, Bridge Pavilion, Zaragoza, Spain. Building No. 51, 2009, JS Bach Pavilion, Manchester, England. Building No. 52, 2009, CMA CGM Tower, Marseille, France. Building No. 53, 2010, MAXXI (the National Museum of the 21st Century Arts), Rome, Italy. Building No. 54, 2010, Guangzhou Opera House, Guangzhou, The People's Republic of China. Building No. 55, 2012, Pierres Vives, Montpellier, France. Building No. 56, Vilnius Guggenheim Hermitage Museum, Vilnius, Lithuania. Building No. 57, 2007, Serpentine Gallery Pavilion, London. Building No. 58, Spiral Tower, Barcelona. Building No. 59, Madrid Civil Courts of Justice, Madrid, Spain. Building No. 60, Kartal-Pendik Masterplan, Istanbul, Turkey.

7.3. Students' perception questionnaire

To evaluate creativity perception, PCDA questionnaire was used (students' Perception of Creativity in Deconstruction Architecture). It consisted of 7 pages; each having a number of buildings to be rated. Before students were asked to fill in the questionnaire, they attended lectures on deconstruction architecture, where the work of the seven pioneers of deconstruction was presented and all the needed data for rating the buildings was provided; along with an explanation of the questionnaire components and how to fill it. Please see Fig. 1. The questionnaire was composed of 32 indicators, which reflected 8 major dimensions of architecture that used to

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Evaluation Questionnaire on Deconstruction Architecture - please mark cells with: Strong presence "S" - Moderate "M" - Weak "W" - Non existant "N"													
	Building 1	Building 2	Building 3	Building 4	Building5	Building 6	Building 7	Building 8	Building 9	Building 10	Building 11	Building12	Building 13
1- Unity and Continuity													
1.1. Singuliarty in geometrical form													
1.2. Dominance clearance													
1.3. Power of contrast													
1.4. Harmony													
1.5. Unity													
2- Repose													
2.1. Structural dynamic repose													
2.2. Structural absence of static repose													
2.3. Formal repose													
3- Scale													
3.1. Human scale													
3.2. Personal scale													
3.3. Monumental scale													
3.4. Urbanistic scale													
4- Rhythm representation													
4.1. Linear													
4.2. Planer													
4.3. Masses & spatial													
5- Proportion													
5.1. Figurative elements													
5.2. Metaphysics													
5.3. Geometrical form													
5.4. Rational													
6- Creative Effort													
6.1. Contradiction													
6.2. Variety & pluralism													
6.3. Complexity													
7- Truth													
7.1. Architectural truth													
7.2. Functional truth													
7.3. Structural truth													
7.4. Technological truth													
7.5. Character													
8- Image													
8.1. Realistic													
8.2. Expressioistic													
8.3. Perfection													
8.4. Novelty													
8.5. Urbanistic													

Fig. 1. PCDA questionnaire.

measure students' perception; namely, unity and continuity, repose, scale, rhythm representation, proportion, creative efforts, truth, and image. The students' evaluation rated the creativity of deconstruction architecture from their points of view with respect to the previously mentioned dimensions [20]; where: S is Strong presence, M is Moderate presence, W is Weak presence, and N is Non existent.

Explaining the components:

A. Unity and Continuity: with respect to singularity or multiplicity, and whether building parts are getting perceived as a whole or as separate parts, and if most of the building masses are oriented towards a certain mass of the composing masses or not. Hence, this dimension evaluated with respect to singularity, dominance, contrast, harmony and overall unity.
B. Repose: the term mainly discusses the stability of the structure and how a receiver can perceive it within his point of view. Repose is either static; with mainly vertical and horizontal masses mostly perpendicular to the earth, or dynamic; with slopes of lines, planes, and masses which could even be opposite in direction. This dynamism shows the capabilities of building materials and how the architectural composition can resist instability. There is a third repose, which is called form repose; where form stability is explained through both the lines and planes.
C. Scale: how the building appears in the surrounding environment, where the scale could be human, of personal preference, monumental or as an urban landmark.
D. Rhythm: linear rhythm, planer rhythm, or a rhythm of masses (spatial).
E. Proportion: with respect to psychological impressions as in: figurative, metaphysical, geometric, formal or rational, in terms of structure and function; such as the proportion of building parts to one another or as in the openings and the relations between solids and voids in the architectural composition.
F. Creative effort: which appears in three aspects: contradiction, variety/pluralism, and complexity, where these are strongly expressed aspects in deconstruction architecture.
G. Truth: be it architectural truth; which means how the building suits the environment via the designer's response to environmental needs, or functional truth; showing and confirming the building function through the form which is mostly absent in deconstruction as the function is usually very hard to recognize, or structural truth; clearly showing the structural elements supporting the building, or technological truth; reflecting how progressed the designer is in using new materials, and finally character truth; with its social, political, or even religious essence.
H. Image: whether it's realistic; showing structural elements and a rational material presentation in the composition, or expressionistic; having freedom in composition, or perfect; meaning adapting the building to suit the general taste through enhancing architectural elements, or novel; like an out of the box idea that's completely far from common thinking, or finally urban; that is following a certain pattern which is a bit hard to find in deconstruction architecture [20].

8. Data analysis and methods [21]

The questionnaire was tested for validity and reliability on an experimental sample presented for no less than 30 persons to measure how reliable and valid it was before it was applied with the target students. All the statistics were done using the Statistical Package for Social Sciences; SPSS version 23. Students' responses were collected on a triple Likert scale, which is mostly used as a ranking tool. The questionnaire questions gave options from which the students should choose, and these options were given numerical values in order to be measured, where the ranking given to each building with respect to the presence of each of the eight dimensions has varied between "Strong = 3", "Moderate = 2" and "Weak = 1".

Reliability of the questionnaire was tested and appeared to be high, through calculating Cronbach's Alpha which varies from 0 to 1 and is considered the most famous measure of reliability that is based on achieving the same results with the same person upon trying the very same experiment several times. Based on Cronbach's Alpha, validity has also been calculated showing how

suitable the questions were for measuring perception, and is also apparently high, as seen in Table 1.

In order to achieve the research objectives, the following statistical methods were applied:

- Descriptive statistics: such as calculating the mean (average) of students' responses as the mean is given to each dimension in relation to every group of buildings of the seven pioneers.
- Factor analysis: which is an advanced statistical technique used for data reduction to aggregate high numbers of variables into one factor. The factor analysis is used to build an index of students' perception to the dimensions of deconstruction architecture.
- Discriminant analysis: which is used to differentiate between; juniors and seniors based on their levels of perception. It is considered a classification tool for the audience, classifying it into two groups depending on their degree of perception. It predicts that anyone answering the questionnaire can be classified as either a senior or a junior according to his answer [21].

8.1. First: Descriptive statistics (students' responses on the seven pioneers of deconstruction architecture)

This is a summarized descriptive analysis of students' responses; where Table 2 shows the mean of students' responses on the presence of the different dimensions of deconstruction architecture, according to the seven pioneers. In this triple Likert scale, when the mean ranges from 1 to 1.66, this refers to weak presence, for a mean ranging from 1.67 to 2.33, this refers to a moderate presence and if the mean ranges from 2.34 to 3, this indicates strong presence. From Table 2, the research reached that the highest dimension present was the "image" dimension, followed by "truth".

8.2. Second: Factor analysis (deconstruction architecture index of perception)

The factor analysis technique was used to turn the 8 dimensions of perception into one index that represents the total perception of all dimensions of deconstruction architecture. Two stages of factor analysis were applied, first; an index of each dimension had been built to reduce the responses of students on each pioneer's buildings which were considered as variables into one index, second; the produced indices were considered as variables to build the final index of students' perception.

The steps of analysis were as follows:

First, an average indicator was computed as the arithmetic mean of responses by measuring the items within each dimension, reflecting the general student response on that dimension as a whole. Then, another average was conducted from the number of buildings by each pioneer of deconstruction architecture. For example, the dimension of unity, U_i, was computed as follows, as U for unity and i is a counter varying from 1 to 7 to represent the pioneers:

$$U_i = \sum_{j=1}^{5}\sum_{k=1}^{n} u_{ijk}, i = 1, \ldots, 7, \quad (1)$$

n = the number of buildings, varies from one pioneer to the other
i = the pioneer
j = items inside the dimension; here: unity sub divisions
k = the counter for the buildings, reflecting the number of buildings by each pioneer
U ijk= student score for unity subdivisions for every pioneer

This equation is to reduce the original data into seven pioneers as variables of unity that will be later aggregated into one index of unity. This operation is repeated to every dimension.

Second, the factor analysis was used to build an index for each dimension of perception allowing a different weight for every group of buildings by a certain pioneer in relation to every dimension. For example, an index of unity was created from the scores of unity calculated from the students' rating of unity sub divisions within each group of buildings corresponding to the pioneers of deconstruction:

$$Unity = 0.124 \times U_1 + 0.153 \times U_2 + 0.188 \times U_3 + 0.220 \times U_4 + 0.207 \times U_5 + 0.201 \times U_6 + 0.201 U_7 \quad (2)$$

Here, it is worth mentioning that each U_i has an adequate value of communality; where if any pioneer data was weak with respect to the measurement of communality, it would be automatically excluded from the index. However, none of the seven pioneers' indicators per each dimension was excluded from the analysis.

In Table 3, the analysis found the factor loadings; which represents the relation between the full index of unity – for example – and each pioneer's indicator. it can be noticed that the students observed Unity and Continuity in Gehry buildings as it has the highest factor loading 0.892 in this dimension followed by Eisenman buildings with factor loading 0.840 and so on for interpreting the rest of factor loading for every dimension and for every pioneer buildings as well, Also component score coefficient was found; which is the share of every pioneer's indicator into the full index

Table 1
Reliability and validity of the questionnaire.

Serial	Dimension	The Cronbach's Alpha	Validity
1	Unity & continuity	0.973	0.986
2	Repose	0.954	0.976
3	Scale	0.964	0.981
4	Rhythm representation	0.966	0.982
5	Proportion	0.964	0.981
6	Creative efforts	0.962	0.980
7	Truth	0.977	0.988
8	Architectural image	0.983	0.991
Total dimensions of perception		0.993	0.996

Table 2
Mean of students' responses on the dimensions of deconstruction architecture according to the 7 pioneers of deconstruction.

Dimensions	Pioneers							
	Tschumi	Himmelidon	Libeskind	Gehry	Eisenman	Koolhass	Hadid	Total
Unity and continuity	1.5	1.2	0.9	0.8	0.7	0.4	1.0	34.3
Repose	1.6	1.3	1.1	0.9	0.7	0.5	1.1	36.9
Scale	1.4	1.2	1.0	0.8	0.7	0.5	1.0	33.8
Rhythm representation	1.6	1.3	1.1	0.9	0.8	0.5	1.1	37.4
Proportion	1.5	1.2	1.0	0.9	0.7	0.4	1.1	35.7
Creative effort	1.4	1.3	1.0	0.8	0.7	0.4	1.1	35.8
Truth	1.7	1.3	1.1	0.9	0.7	0.5	1.1	37.6
Image	1.6	1.3	1.1	0.9	0.8	0.5	1.2	39.0

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Table 3
The factor loadings of the indicators and the component score coefficients of the dimensions of perception according to the pioneers of deconstruction architecture.

Pioneers	Factor loadings								Component score coefficients							
	Unity and continuity	Repose	Scale	Rhythm representation	Proportion	Creative effort	Truth	Image	Unity and continuity	Repose	Scale	Rhythm representation	Proportion	Creative effort	Truth	Image
Tschumi	0.504	0.363	0.417	0.439	0.400	0.530	0.385	0.474	0.124	0.088	0.101	0.103	0.100	0.122	0.092	0.110
Himmeliden	0.623	0.646	0.656	0.684	0.587	0.582	0.649	0.689	0.153	0.157	0.158	0.161	0.147	0.134	0.154	0.159
Libeskind	0.765	0.795	0.774	0.850	0.724	0.792	0.802	0.814	0.188	0.193	0.187	0.200	0.182	0.182	0.191	0.188
Gehry	0.892	0.909	0.896	0.916	0.899	0.899	0.902	0.916	0.220	0.220	0.216	0.216	0.226	0.207	0.215	0.212
Eisenman	0.840	0.856	0.876	0.829	0.875	0.902	0.876	0.869	0.207	0.207	0.211	0.195	0.220	0.207	0.208	0.201
Kolhass	0.818	0.855	0.850	0.825	0.842	0.870	0.869	0.849	0.201	0.207	0.205	0.195	0.211	0.200	0.207	0.196
Hadid	0.816	0.810	0.806	0.808	0.821	0.851	0.807	0.805	0.201	0.196	0.194	0.190	0.206	0.196	0.192	0.186
Adequacy measures	58.05[a]	58.94[a]	59.24[a]	60.61[a]	56.93[a]	62.15[a]	60.05[a]	61.77[a]	0.78[b]	0.805[b]	0.825[b]	0.813[b]	0.797[b]	0.846[b]	0.830[b]	0.849[b]

[a] Total variance explained.
[b] KMO measure of sampling adequacy.

of unity, for example, which is an iterative step repeated with each of the eight dimensions of perception.

From the component score coefficients in Table 3, Sampling Adequacy was calculated (**), which reflects how suitable every pioneer is for applying factor analysis. It had a minimum of 0.78; indicating that the factor analysis suited the indicators and none of them needed to be excluded from the analysis. Total Variance, another tool for checking how good the model is, was calculated from the factor loadings. It had a value for each index with a minimum of 58%, see Table 3. This level is acceptable for this kind of study. Bartlett's Test of Sphericity; which is a test used to measure the model significance, was also used and the indicators appeared significant.

Finally, factor analysis was applied one more time to calculate total weights for each dimension and demonstrate the 8 dimensions of perception into one composite index. Factor analysis method doesn't assume a predefined load of deconstruction perception dimensions, but the results were built upon students responses, yielded that the dimensions have almost close loads. In Table 4, the factor loadings and the component score coefficients of the 8 dimensions of perception are demonstrated. As the highest load was for image dimension 0.989 while the lowest load was for scale dimension 0.968.

From Table 4, it can be noticed that the measure of sampling adequacy (**) for the students' perception index is 0.91 which indicates that factor analysis does suit all indicators and none of them needs to be excluded from the analysis, while Total Variance Explained by each one of the indices was about 97%.

A perception index was created with a range of −1 to 1. This range was divided to three thirds to formulate the lowest, moderate and high levels of perception; where a label of "1" represented the lowest level of perception, a label of "2" represented a moderate level of perception and a label of "3" represented the highest level of perception. Then, the frequency distribution of the students according to the level of perception index was calculated, as displayed in Table 5.

Table 4
The factor loadings of the indicators and the component score coefficients of the dimensions of perception.

Dimension	Factor loadings	Component score coefficients
Unity and continuity	0.979	0.126
Repose	0.982	0.127
Scale	0.968	0.125
Rhythm representation	0.990	0.128
Proportion	0.993	0.128
Creative effort	0.981	0.127
Truth	0.988	0.128
Image	0.989	0.128
Adequacy measures	96.8[a]	0.909[b]

[a] Total variance explained.
[b] KMO measure of sampling adequacy.

Table 5
The percentage distribution of students according to levels of perception of deconstruction architecture.

Levels of perception	Frequency	Percent (%)
Lowest "1"	20	24.7
Moderate "2"	41	50.6
Highest "3"	20	24.7
Total	81	100.0

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Table 6
The percentage distribution of juniors and seniors according to levels of perception of deconstruction architecture.

Students' academic year	Levels of perception			Total numbers
	Lowest "1"	Moderate "2"	Highest "3"	
Juniors	15.0%	48.8%	89.0%	41
Seniors	85.0%	51.2%	11.0%	40
Total numbers	20	41	20	81

8.3. Third: Discriminant analysis-perception of deconstruction architecture of juniors as compared to seniors

The major assumption in this research was to know "how much the perception of the philosophy of deconstruction is affected by the scientific content learned by students during their academic years of study", Chi-square test was used, which is a test that measures the association between two categorical variables (here the two academic years) and the relevant level of perception. The test assured that there was a significant association between the students' academic years of study and their levels of perception of deconstruction architecture see Table 6.

In order to explore whether the dimensions of perception could be used as predictors to distinguish students of one academic group from the other, a discriminant analysis [22] was used which yielded into one discriminant function that was based on the students' responses on the questionnaire; and which classified the students to be junior or senior. The function acts as a projection of data that best separates or discriminates between these two academic groups. The eigenvalue is one of the important measures of the quality of the discriminant function and describes how much a function possesses a discriminating ability. The magnitude of the eigenvalue is indicative of the discriminating abilities of the function; where the closer the eigenvalue is to 1, the higher is the ability of the function to discriminate between groups. The eigenvalue of the discriminant function of the academic groups was equal to 0.765, which is very reasonable.

Another quality measure is the significance of the canonical correlations. In other words, the null hypothesis is that the function has no discriminating ability. This hypothesis is tested using the Chi-square statistic which equals 66.005. This null hypothesis is rejected at a 0.001 level of significance. Here, it can be noticed that the canonical correlation value was significantly far from zero.

The following equation is used to calculate the function score:

$$score = -1.241 \times zunity + 2.464 \times zrepose + 0.208 \times zscale + 0.416 \times zrhythm + 2.449 \times zproportion + 0.759 \times zcreativity - 2.88 \times ztruth - 1.347 \times zimage \quad (3)$$

zdimension = standardized (average) value of dimension

Every dimension was considered as a variable, in order to discriminate between the two categories of students. Since every dimension had a different weight in each group, with the increase in the absolute value coefficient of a dimension, its importance in discrimination increased.

The magnitudes of the standardized canonical discriminant function coefficients indicate how strongly the discriminating variables affect the score. For example, the standardized coefficient can be seen for ztruth in the previous function is greater in magnitude than the coefficients of the other variables, or in other words, ztruth had the highest absolute coefficient that governed the difference between senior and junior students.

The Function at Group Centroids was calculated afterwards, where these are the means of scores of the discriminant function calculated for each group. The function at the first group centroid (juniors) differed remarkably from its value at the second group centroid (seniors), with values 1.159 and −1.188 respectively and that is what discriminated seniors from juniors.

Table 7
Classification results.

Students' actual academic year	Predicted group membership		Total
	Juniors	Seniors	
Juniors	35	6	41
Seniors	1	39	40

From Table 7, it can be noticed that about 92% of the originally grouped cases is correctly classified by the discriminant function in Eq. (3). Students' answers were used to create the index that classified the students to be juniors or seniors. 35 juniors were predicted correctly and 1 was wrongly predicted, while 39 seniors were predicted correctly and 6 were wrongly predicted. Thus, the answers-based prediction resulted in a correct classification of juniors and seniors with a 92% accuracy level.

9. Findings

The descriptive analysis shows that the students gave high rates of the "Image" dimension in the majority of pioneers' buildings while they rated the "Scale" dimension as the lowest. Please see Fig. 2.

The factor analysis revealed that the median of the index of perception of juniors higher than that of seniors, while seniors have higher level of dispersion than juniors. Refer to Fig. 3. This is in addition to the factor loadings of dimensions in relation to pioneers revealed a different result than the descriptive analysis of students' rates. Please see Fig. 4.

The discriminant analysis shows that juniors perceived deconstruction architecture according to index of perception higher than seniors even they didn't have the knowledge or learned it. Please see Fig. 5. As the highest dimension responsible of distinguishing junior level from senior level is the truth dimension. Please see Fig. 6.

10. Discussions

This research investigated the students' perception of deconstruction architecture and how perception is affected by the ways architectural theories are being taught to them.

Previous literature assumed that there was an arrangement in perceiving architecture introduced by professor Raafat, by arranging what to be perceived in order of what would naturally be seen first; unity and continuity had been usually seen first, then stability and scale, afterwards rhythm and proportions are given a deep look, then the receiver mentally starts to outline the creative effort of the architectural product, reaching the concept and formulating his final image of perception. This contradicts with the current research findings which showed that the students have higher perception of image, truth, rhythm representation, repose and creative efforts, if compared to their perception of unity and continuity,

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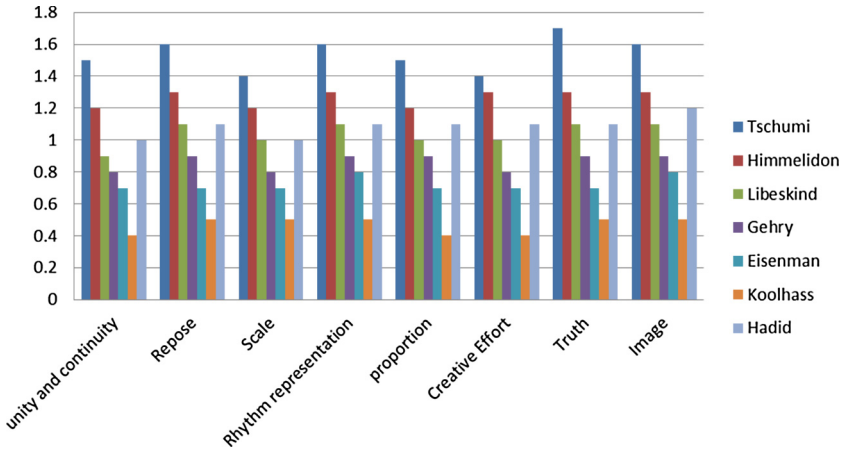

Fig. 2. Mean of students' rates of dimensions in relation to pioneers.

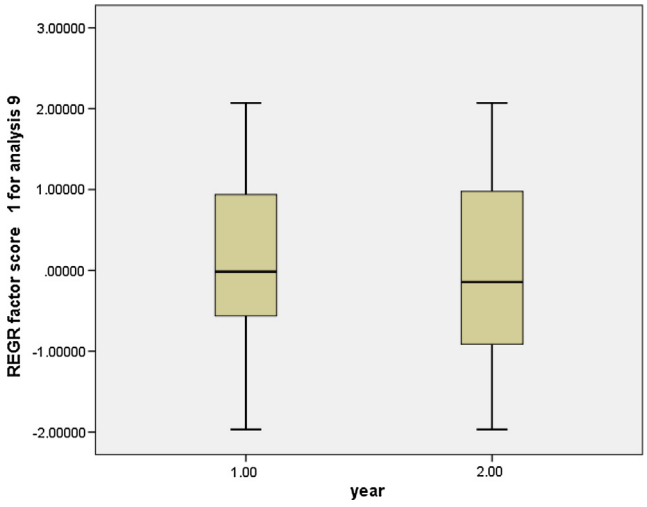

Fig. 3. Box plot of students' index of perception by academic year; "1" is for juniors and "2" is for seniors.

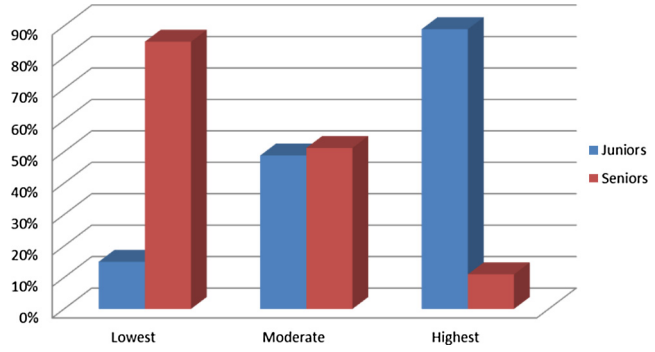

Fig. 5. The percentage distribution of students in relation to their level of perception.

proportion, and scale; as they give higher rates on Likert Scale of the former dimensions than the later ones.

If the students' perception aggregated upon the eight dimensions and analyzed in relation to the seven pioneers' buildings presented to them, it can be concluded that students' perception of pioneers can be ranked from the most perceived to the least perceived as follows: Gehry, Eisenmann, Kolhass, Hadid, Libeskind, Hemmilid and Tshumi. This rank of pioneers' buildings is more precise than the results of descriptive analysis shown in Fig. 2 as the factor analysis technique allows different weights of dimensions of perception for each group of buildings.

Meanwhile, if the students' perception of each dimension of perception is analyzed individually, it can be noticed that the highest indicator correlated with the index of "Unity" is that of Gehry's, which shows that his work highly exhibits "unity and continuity", followed by Eisenman. Also, Gehry's work shows a high degree of

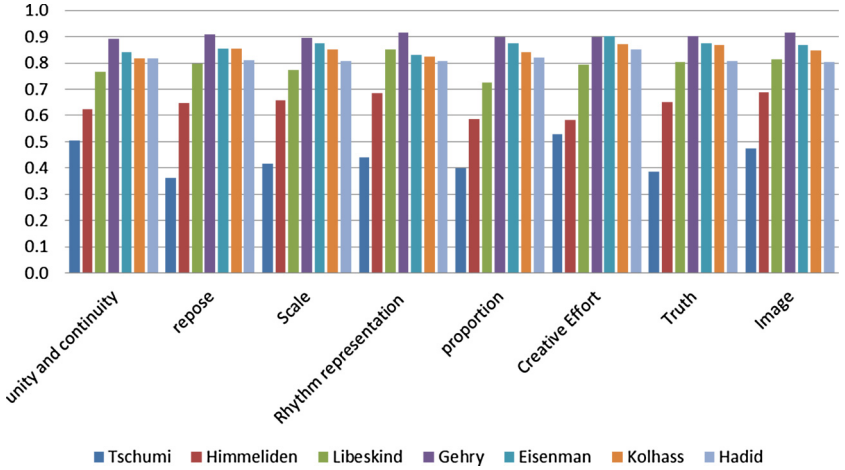

Fig. 4. Factor loadings of the indicators of the dimensions of perception in relation to pioneers.

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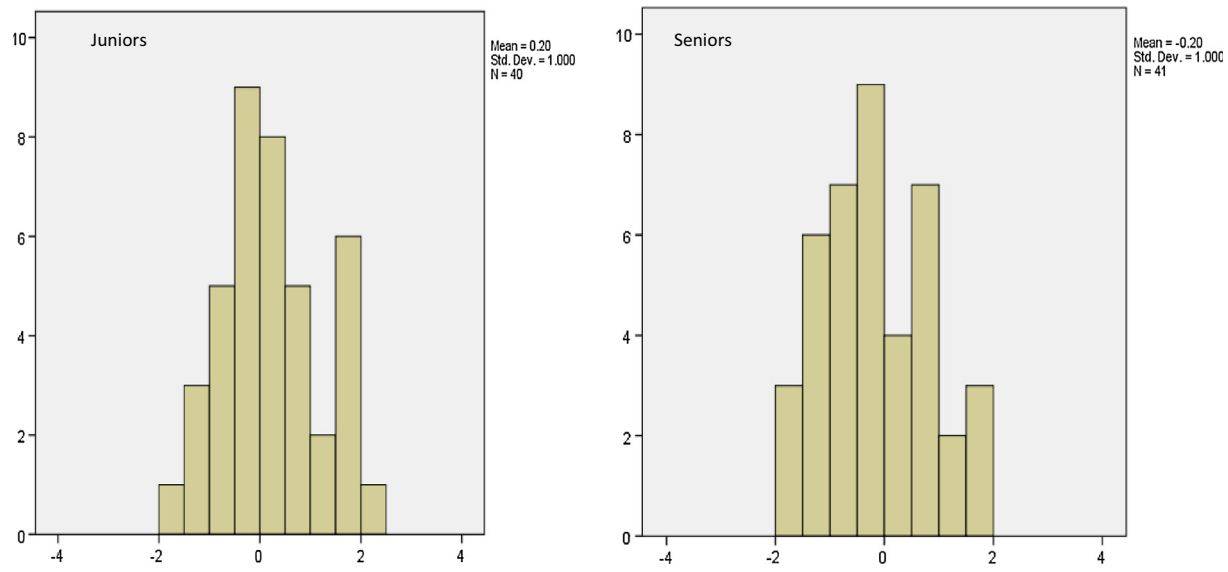

Fig. 6. The frequency distribution of juniors and seniors according to the canonical discriminant function scores.

"Repose", "Scale", and "Proportion"; followed by Eisenman. As for the index of "Rhythm Representation", Gehry's work is very representative, followed by Libeskind. Regarding "Creative Efforts", Eisenman's work shows the highest level of creativity form the students' point of view, followed by Gehry. The work of Frank Gehry exhibits a high degree of "Truth" and "Image", followed by Eisenman.

One of the unexpected results of the research, each one of the eight dimensions of perception has almost the same load of perceiving deconstruction when they are merged among pioneers' buildings.

The canonical discriminant function shows that the absolute discriminant score value of the dimension of "Truth" had the greatest impact to distinguish between juniors and seniors, among the eight dimensions followed by "Repose", whereas the least impact was that of the "Scale" dimension.

The discriminant analysis revealed that juniors have higher levels of perception if compared to seniors, with almost 90% of them with perception score in the highest level of perception.

11. Research conclusion

The previous findings and discussion fulfil the research main objective by proving statistically that juniors have higher level of perception of deconstruction architecture than seniors who received an educational an scientific materials on theories of architecture generally and deconstruction, specifically. In addition to that the index generated from the analysis can be used as a tool of evaluation to ensure that the students reached a proper level of perception targeted, as the way of teaching should suit the architectural theory values to achieve better understanding of architecture philosophy, the added value by this research is to let the students criticizing by questioning to formulate their own point of view and they must be allowed to think differently, even tutors should teach them how to think and perceive freely, especially that the main objective of teaching architecture is not to produce a prototype students in their point of views and thinking strategies. Another recommendation to students themselves, juniors should be taught early in thinking by the tutors and by themselves to read critically and come back with questions not to start that training in their pre-final year, and for seniors; to value the philosophy behind any architectural product based on their research not only from the given information, this research raised a question of how the scientific material can affect students levels of perception and the answer proved that there is an effect, this effect can be treated by fixing the weak points in students perception which revealed in this research.

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