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The Architectural Building Blocks of Innovation: a comprehensive metric for developing innovative spaces

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Executive Summary

Innovation is a global hot topic. Conceptually, policymakers, stakeholders, and researchers with a variety of backgrounds need to understand what innovation is? Moreover, how it can flourish? Architects and urban planner work on interpreting innovation in a planned manner with time and space limitation. This research is trying to fill the gaps between strategy bases studies and practical aspects of designing, organizing and sustaining innovative spaces within four different scales: city, district, building and single space.
Thus, this research covers four parts: Firstly, the literature reviews for a broad spectrum of innovation-interrelated topics. Secondly, a study for the deeper understanding of innovation as a process through mapping it through time and space.Thirdly, demonstrates the outcomes of a survey was conducted to define the characteristics of innovative space. Finally, part four is summing up a matrix of indicators to be used as design checklist or measurement tool for the impact of innovation areas and Science Parks on their surrounding communities.

Keywords: workplace, spatial configuration, innovative spaces, social innovation, metrics.

Introduction:

Many cities, regions and corporate around the globe are working on developing several projects, trends and concepts to magnetize the global talents for joining their local markets. At the micro level of the global talent pool, this generation of innovators is drawing higher attention to their work environment, provided facilities for them and their families and finally, the offered incentives in the case of moving to these innovation magnets.

When we combine the macro and micro pictures, we can notice that a major dilemma presents itself. In what way can architects develop innovation economies? Moreover, what confidence can they have in those roles considering the lack of evidence about the "monolithic" urban configuration and architectural setting of innovation areas within a context of uncertain and conflicting global innovation agenda?

That is why, policy makers, stakeholders, and outstanding innovation firms are seeking more precise and measurable indicators for evaluating the ability of their economies, regions, and company in attracting the world's best innovators.[1]

In response to this dilemma, this paper is focusing on establishing a group of indicators related to the built environment of innovation. It perceives the global innovation map from the architectural point of view. Also, it is targeting to find some shared architectural characteristics that provide exclusive distinction for some innovation clusters, university campuses, and STPs than others. This goal can be achieved by engaging the discipline of architecture more actively in innovation as a process.

[1] Imperative, T. M. (2008). Innovation Metrics. *Innovation, 25*, 1–3. http://doi.org/10.1108/02580540910943550

This paper is organized based on two premises, the first straightforward is, *hypothesizing that the architectural characteristics and configurations of a particular space may increase or decrease the possibilities of innovation to take place.* The second premise is more holistic, *assuming that there is a kind of correlation between City, district and space concerning fostering interaction and thriving innovation*. Accordingly, the research is a trial to articulate the parameters which may control the efficiency of those three levels of spaces to promote innovation within a comprehensive ecosystem.

The principal goal of the paper is to influence the thinking of innovative managers, architects, and city planners by broadening their consideration when planning and designing both the organizational setting and the physical space of innovative spaces. This research is trying to establish a universal language that brings these disciplines together—in the context of the innovation process—to become no longer thinking about the two tools of social configuration, organizational structure, and physical environment in isolation, one from the others.

1.literature review

In fact, literature on innovation was focusing on two related issues: business enterprise innovation and technological innovation and it is application considering how to match technology to the market need. The architectural characteristics and parameters of innovative spaces were only oriented towards the arrangement of workspace or study classroom to foster collaboration and innovation in a holistic fashion. Also, Previous studies about innovation covered the following topics:

1.1 Economic innovation: which is related to business development for new products and processes. The metrics of economic innovation depends on the mechanical parameters of inputs and outputs. Innovation was viewed linearly, accordingly, economic innovation measurements focused on production systems with the input-development-output mode.[2] However, today, innovation is a multidimensional process that cannot be measured with a single indicator. While the knowledge economy is unfolding around us, The currently available measurements reflect products and artifacts rather than ideas and processes.[3]

1.2. Livability and innovation: as a contemporary term, Livability reflects the personal satisfaction with his/her used area.This term has some historical roots, starting by Aristotle, who used the term "eudaimonia" to mean living well or doing well[4].The popular work of Maslow in his hierarchy of needs, He ranked a five set of hierarchies, beginning with the physiological needs being met, safety and security, loving and belonging, esteem, and finally, at the top of that hierarchy, self-actualization. Recently, Designers made lots of use of this pyramid of needs in designing spaces. Finally, Reiss outlined a collection of socio-economical aspects as basic drivers for livability, such as power, curiosity, independence, status, social contact and others.[5] Of Course, this literature review of livability indicators will serve the research in defining the physical features of well-designed space of innovation.

1.3. The quantitative aspect of ranking the quality of life in cities: which had emerged during the nineteenth century when governments began gathering and analyzing social and economic indicators on

[2] Atun, R. a., Harvey, I., & Wild, J. (2007). ***Innovation, Patents and Economic Growth***. International Journal of Innovation Management, (02), 279–297. http://doi.org/10.1142/S1363919607001758
[3] Innovation Metrics: Measurement to Insight. (n.d.). Retrieved from http://innovate.typepad.com/innovation/files/innovation_metrics_issue_paper_1.4%
[4] Wagner, F., & Caves, R. (2012). ***Community Livability: Issues and Approaches to Sustaining the Well-Being of People and Communities***., Routledge
[5] Zelick, P. R. (2007). ***Issues in the psychology of motivation***. New York: Nova Science.

a national scale. Significantly, with rapid urbanization in the postwar period, the city emerged alongside the nation-state as a viable unit of analysis. At this point, intergovernmental agencies, alongside the national organizations, became active in auditing and measuring and tracking the different aspects of city-related phenomena. The most related to our topic is the index of "the Most Livable City" by Monocle magazine. The criteria of this metric involve safety and crime, international connectivity, the climate, quality of architecture, public transportation, tolerance in the public realm, environmental issues, access to nature, urban design, business conditions, proactive policies, and medical care. The major targeted group by Monocle index is the global creative and talented middle class, which is the targeted group of this study as well.

1.4. Planning of innovative districts and workplaces. Zundel[6] densely studied this topic in finding a comprehensive framework for developing innovative districts. His research project tried to find some answers to the question of: "What role(s) and degree of confidence can be planning, and design professionals play in the development of regional innovation economies, especially considering the lack of evidence tying urban sites to the larger system?". The most interesting findings of Zundel's study determined the role of places in innovation systems and how to use urban redevelopment to foster innovation and the roles planning/design professionals play in the process of cataloging new tactics for land development.About regional innovation system, Zundel's study helped in linking between the understanding of regional innovation systems and the value of land development projects in improving those systems. Also, it concluded that successful developments increased innovation in their local economy via urban planning and design tactics.

1.5. The organizational structure and built environment of innovation: The work of Thomas Allen and Gunter Henn[7] about The Organization and Architecture of Innovation was focusing on bridging the gap between the business organization of workplaces and architectural space planning of office spaces. Their extensive study concluded that these two management tools—organizational structure and physical space—are partners in moving the innovation process forward. This mission requires the intelligent combination and use of physical space and organizational structure. Neither by itself is sufficient.

It was one of the earliest design-based research that goes well beyond the observation of "best practice" or isolated case studies as it includes the issue of the appropriate organizational structure for innovation and the product development process, which can be designed on a rational basis.[8]

2. Understanding innovation:

The most confusing thing about innovation is its definition and its organization. As a simple definition, innovation in an invention with exploitation. Also, innovation can be recognized as a magical mix between creativity, knowledge, Spark with imagination and fuel with data. To understand innovation as an idea, we need to demystify it into conception, organizational structure, and process.

2.1. The conception of innovation: The architects who create buildings for organizations engaged in innovation must go far beyond their traditional programming process. They need to understand the role

[6] Zundel B., (2013), ***Explore. Develop. Innovate: Urban Development for Innovation Economies***. Master's Thesis, Kansas State University, Manhattan, Kansas, USA.

[7] Allen, T. J., & Henn, G. (2007). ***The organization and architecture of innovation: Managing the flow of technology***. Amsterdam: Elsevier.

[8] Coleman, C., Graham, M., & Mulhern, T. (2012). ***Framework for Innovation Spaces Research and Design Thinking***, Gensler. Retrieved May 01, 2012, from http://www.gensler.com/design-thinking/research/framework-for-innovation-spaces

of different types of innovation, communication and the desired patterns of interaction within their clients' organizations. Christensen stated that there are two categories of innovation[9]:

- ***Sustaining innovation*** as an improvement mode to something already exists. Also, it is the ability to use resources in a new, clever or unexpected way to solve a specific problem in a particular context. Which is creativity?[10]
- ***Disruptive Innovation*** is the other category of innovation, which is opening new frontiers of imagination for creating entirely new products, services or even a whole new market.

The increasingly competitive markets of today require nations, cities and companies to use both disruptive (imagination) and sustaining innovation (creativity) to overtake the global market. In other words, both creativity and imagination are acting as two wings for innovation to soar through new horizons and generate new ideas.

To facilitate innovation, Communication is a mandate. The more integrally communicated are the innovative team(s) the more ideas might be mingled to retain the organization's efforts to hatch, incubate and develop innovative products, services or processes.

There are three types of communications for better innovation[11]:

- **Information communication:** Which is more related to basic knowledge and references. This sort of communications is occurring within the same discipline or department to discuss a specific technical expertise.
- **Coordination Communication**: this type of communication is required among team members from closely related specialties or disciplines who are working on the same project to assure that their scattered pieces of the mosaic will be assembled safely as a final product.
- **Inspiration Communication:** the most complicated level of innovative communications, is built on gathering a vast variety of minds from different backgrounds (science, art, and engineering) to think imaginatively to interweave radically new ideas.

2.2. The organizational structure of innovation:

2.2.1. Department-based innovation

Historically, organizations tended to control the flow of innovation process as an industrial mass production line. Dividing the institution into a group of departments with different, but related, specialties who are working together to create the final product along a ***technology stream*** of activity. At that time, production mode was more oriented towards ***creativity or sustaining innovation***. (figure 1(a))

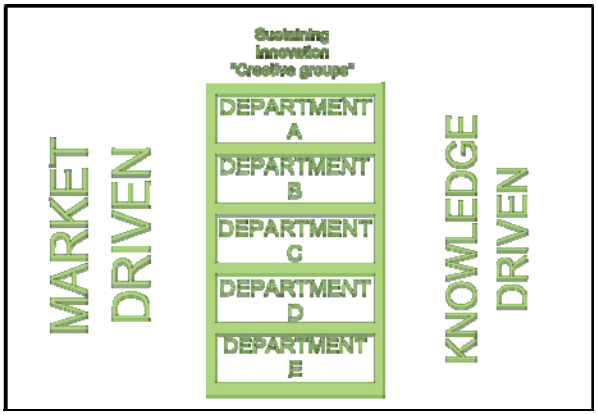

Fig.(1-a) The technical department organization (source: Author)

[9] Christensen, C. M. (1997). ***The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail***. Harvard Business School Press. Retrieved from http://books.google.de/books?id=SIexi_qgq2gC

[10] Equipped for the Future - Assessment Resource Collection, http://eff.cls.utk.edu/assessment/solve8.htm (accessed May 02, 2016).

[11] Allen, T. J., & Henn, G. (2007).

Positively, technical departments' staff can keep in close contact with new developments within their specialties. However, the limitations of this model lay in the mere fact that industry has not had the luxury of avoiding cross-disciplinary work. ***Information communication*** is the dominant mode of exchanging ideas among departments' staff.

2.2.2. Project team-based innovation

Due to the complexity of ***market demands***, the idea of ***project teams*** emerged from companies desire to satisfy the market needs by creating products and services without being aligned with a sole technological specialty or discipline.[12]

Tracking the market's demand in a proactive fashion leads to more predisposition towards creating interdisciplinary teams centered on a project. This model allowed ***coordination communication and imagination or disruptive innovation*** to flourish among the multidisciplinary team members to a certain limit. (figure 1-b)

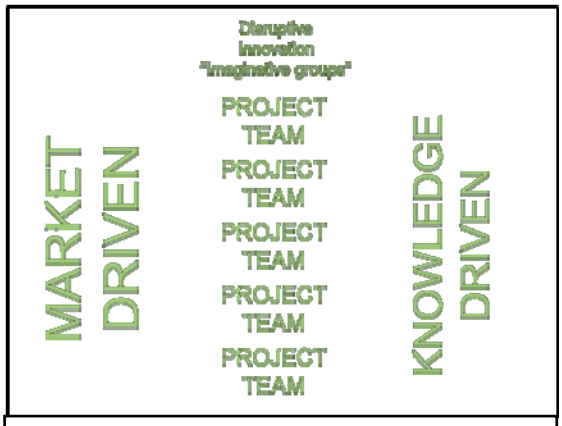

Fig.(1-b) The project-team organization
(source: Author)

On the other hand, this trend had a price of extracting the team members away from their original bases of knowledge-technological departments. They are more likely to lose updates about "state-of-the-art" in their respective specialized areas of knowledge. This dilemma creates a problem in reassigning the resulting prematurely "obsolete" staff to new projects which lead, consequently, the organization to be lagging behind.

2.2.3. the "Matrix"-based innovation

The matrix organization developed to resolve the previous concerns. As project teams, while making intense focus and coordination possible, could not meet the challenge of keeping well contacted with new developments within their specialties.Typically, this trend uses functional supervisors and project supervisors to manage the same people. Lines of liability go in at least two directions in the matrix organization. Which generate a highly competitive environment to let both **sustaining innovation (creativity)** and **disruptive innovation (imagination)** to thrive. (figure 1-c)

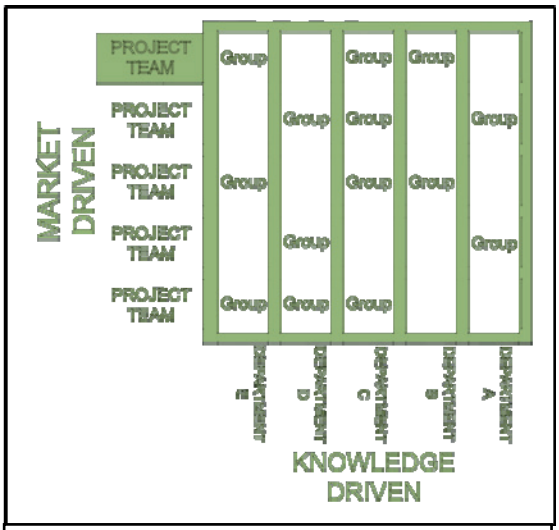

Fig.(1-c) The Matrix organization
(source: Author)

Meanwhile, testifying such a model proofed its organizational inefficiency as people could not work for multiple bosses—the project leader and the department head. This managerial conflict may cause negative competition among different managers to fight for grabbing the most talented resources for their projects or departments.

[12] Organizational Structure for Product Development, https://dspace.mit.edu/bitstream/handle/1721.1/83298/PLN_0102_Allen_Org4ProdDev. (accessed May 02, 2016).

2.2.4. Center of gravity-based innovation

This study proposes a refined edition of "the matrix" model by adding a third layer of interaction as follows (figure 1-d):

a. **A center of gravity** is added to a central area of interaction between technically oriented talents (department based) and market-oriented talents (project based) within a fully flexible space for chaotic and messy but mentored innovation. The composed teams within such a center are highly independent with freedom of location, communication and integration with other bases (technological and project).
b. **The technological departments** remain as the resource of knowledge update and revising the ***validity*** of proposed ideas by the center of gravity.
c. T**he project-based teams** are acting as moderators between both centers of gravity and technological knowledge based departments. Also, these teams will be responsible for revising the ***novelty*** of proposed ideas by the talented groups in the center of gravity.

2.3. The Multi-dimensional ecosystem of innovation: This research assumes that ***there is interrelated bonds within different scales of innovation: the city, district, building, and individuals.Such a complex interwoven connections create an ecosystem for innovation within the city.The stronger is the bond among these factors within mentioned four level, the more likely innovation may flourish and expand.***(figure 2)

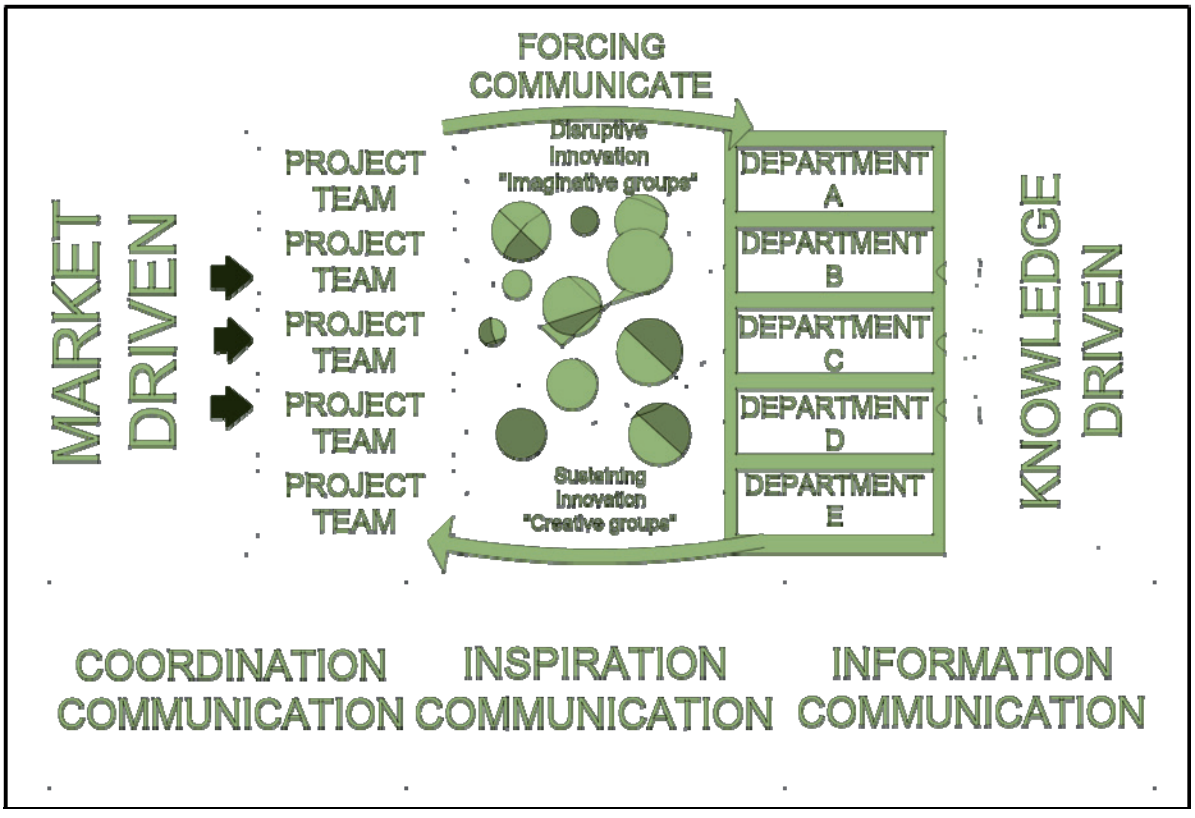

Fig.(1-d) the center of gravity organization
(source: Author)

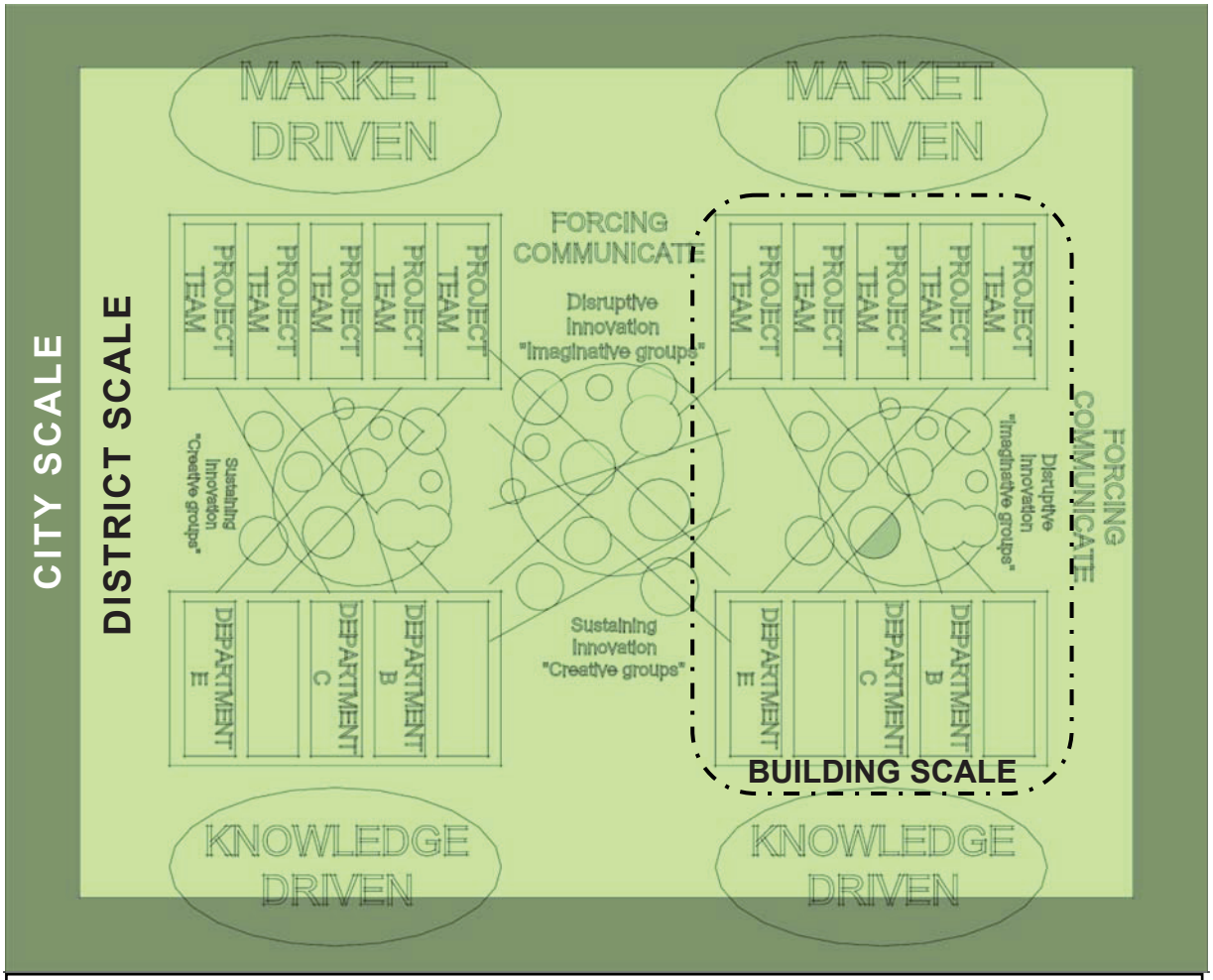

Fig.2 the physical framework of innovation ecosystem
(Source: Author)

These hypotheses are supported by the findings of a secondary and primary researches on innovation conducted by Steelcase[13] .It was retained by a survey of more than 200 corporate real estate practitioners and observation studies with clients that helped to identify innovation behaviors and processes in actual work settings. In fact, the study revealed that some design elements of buildings reduce the opportunities for thriving and innovate. Hence, the importance of physical space for the innovation process are profound; it becomes more important to understand the different types of communication and their impact on innovation.[13]

Another study conducted by Gensler design[14] research team to navigated through a group of case studies for innovation generation spaces it is key findings that one size does not fit all, as each type of innovation within a certain culture is a unique environment. Each environment needs a set of multiple, overlapping design strategies for its spaces to support a particular mode of innovation.

[13] ***Where We Innovate: The Innovation Infrastructure*** .., http://www.innovationmanagement.se/2011/10/12/where-we-innovate-the-innovation-i (accessed May 02, 2016).
[14] Coleman, C., Graham, M., & Mulhern, T. (2012).

The proposal of innovation ecosystem is constructed on earlier thoughts, theories, visions and practically learned lessons from deferent models. This paper presented some proper answers for the major raised questions in a sequentially structured approach to reach this comprehensive framework. The levels of applying this framework are attributed within four hierarchical scales:

- Individual/interpersonal scale:
- Campus /building scale
- district/vicinity urban scale
- city/regional scale

Still, this concept is flexible enough to match various modes of innovation for different innovative industries. Table 1 shows that not all industries are equally related to the four levels of this ecosystem.

For example, Digital applications, education, fashion, and architecture are more enclosed professions which are linked to the institution and the talented workers more than being related to the city or the adjacent context.

	City	District	Building	Individual
Innovative industry[15]				
Aerospace	L	L	**H**	M
Architecture	M	M	**H**	**H**
Art & crafts	**H**	**H**	M	M
Automotive	L	M	**H**	**H**
Digital application	M	**H**	**H**	**H**
Education	L	M	**H**	**H**
Fashion	M	L	**H**	**H**
Film & music	**H**	**H**	**H**	M
Healthcare	L	M	M	M
Industrial design	L	L	M	**H**
Information technology	L	L	**H**	M
Media	L	M	**H**	**H**
Publishing	M	M	M	**H**
R & D	H	L	M	**H**
Telecommunication	H	L	M	**H**

Table 1 the correlation between innovative industries and the four level of innovation ecosystem (source: Author)

2.4. Proposed guidelines for designing, planning, and operating innovation ecosystem:

2.4.1. Individual/group scale:

- **More matrix, less departmental and less project based:** Market needs are defined in the form of products and services and do not necessarily align with departmental specialties or disciplines. In fact, they usually draw knowledge from a variety of disciplines or technologies, thus requiring an integration of knowledge from varied sources.
- **Awareness of *leadership***: to show management as a unified whole. While the executives can retreat to their private offices, the glass walls ensure that they remain visible to everyone in the vicinity.[16]
- **Decentralized Networking**: Changing patterns of the organization affect how people communicate. Centralized hierarchies formed over time by decentralized individuals have now evolved, and more decentralized networks allow for direct communication between people.[17]

[15] Berg, S.-H., & Hassink, R. (2014). ***Creative Industries from an Evolutionary Perspective: A Critical Literature Review: Creative Industries***, Evolutionary Economic Geography

[16] Cronheim, C. C. (2004). ***Creative destruction: How globalization is changing the world's cultures The rise of the creative class: And how it's transforming work, leisure, community and everyday life***. J. Pol. Anal. Manage. Journal of Policy Analysis and Management, 23(4), 932-936. doi:10.1002/pam.20059

[17] Coleman, C., Graham, M., & Mulhern, T. (2012)

2.4.2. Building Scale:

- **Transparency**- visual connection to support the idea that one has the freedom to make one's decisions—that is, within the realm for which one is responsible— but also to influence the decisions of others seen through the glass walls.
- **Common spaces**: In the less-formal setting of a comfortable couch or a coffee bar, the company benefits from the chance conversations, sharing of ideas, and overall interaction that was far less likely to have taken place with the old, closed space configuration.
- ***Possibility***: Organizations, need space where things can happen, where it is possible for the unexpected to unfold. It is in the less formal, open spaces where the chance encounters that are so essential to the innovation process can take place.
- **"centers of gravity"**: building design can promote collaboration by rearranging space and flow so that the activities of individuals and groups unfold dynamically.One of the proper techniques is to centralize social spaces to urge people within varies, groups and teams, to travel to them; this would have a profound influence on traffic patterns and on the possibility that people/groups who rarely communicate might run into each other and interact.
- **Flexible communication modes**: despite its chaotic behavior, innovative spaces should provide ample flexibility for exploiting the three modes of communication: coordination, information, and inspiration. Either within different spaces or in one room.
- **Physical proximity**: regardless how is the organizational structure of the institution, physical proximity between talented innovators from different-even contradicting-disciplines, such as engineers and artists are mandatory for more innovativeness.

2.4.3. Contextual (immediate context scale):

- **Building a collaborative leadership network** within campus, block or district scale (innovation districts)[18]
- **Setting a vision for growth** by providing actionable guidance for how an innovation district should grow and develop in the short-, medium- and long-term along economic, physical and social dimensions.[19]
- **Pursuing talent and technology,** given that educated and skilled workers and sophisticated infrastructure and systems are the twin drivers of innovation.

2.4.4. city/region scale:

- **Promoting inclusive growth by using the city's innovation districts** as a platform to regenerate adjoining distressed neighborhoods as well as creating educational, employment and other opportunities for low-income residents of the city.[20]
- **Integrating arts & culture combinations** in **facility centric** (arenas, cultural centers, incubator space or creative district), **people oriented** (supporting art centres, creating cooperative marketing opportunities, commissioning artworks, **program-based** (gardening, mural making, public art displaying, local art festivals, exhibitions or plays.[21]

[18] Coleman, C., Graham, M., & Mulhern, T. (2012)

[19] Katz, B., & Wagner, J. (2014, May). The Rise of Innovation Districts: A New Geography of Innovation in America. Retrieved May 03, 2016, from http://www.brookings.edu/about/programs/metro/innovation-districts

[20] Katz, B., & Wagner, J. (2014, May).

[21] Zundel B., (2013)

3. Diagnosing the characteristics of innovation generation spaces:

3.1 Methodology:

Thanks to the advances in the science of environmental psychology and the growing influence of design research as a problem-solving methodology, more knowledge is available about how to incubate innovation and let it flourish within the certain spatial configuration.

Thus, a survey has been conducted among a group of architects, architecture students, researchers and innovative industries workers from nine countries (Saudi Arabia, Egypt, Germany, USA, UK, UAE, Qatar, Bahrain, and Canada) To justify our research's hypothesis.The survey's targeted group was those who are studying, teaching and practicing architecture and urban design to inquire about their vision for innovation as a process and to collect ideas about the architectural characteristics and spatial properties of innovative space. Architects are attached to innovation in a dual manner: they are using generation innovation process to create innovation-deriving spaces although it is messy and nonlinear nature. The survey was composed of a self-designed standard questionnaire.

By analyzing the effect of city, immediate urban context, institutional organization and architectural features of work/study and live spaces on the design education, we tried to reveal surveyed groups' preferences about the most catalyst environment for innovation and its physical characteristics. To this end, 131 participants were inquired in the study, 38 of whom were students at architecture schools, while 52 of them were graduate architects/researchers and 41 were academics and university lecturers in architecture. The collected data about innovators' experiences and desires related to the cities, institutions and buildings they worked in, which could later be used as a guideline for articulating the architecture of innovate spaces.

3.2. Evaluation of the Survey

The findings clearly indicate that most of the participants are aware of the holistic definition of innovation as a mixture of creativity and imagination (70%), and 30% of the group stated that innovation means either creativity (21%) or imagination (12%). While the ratio of participants who claimed that they have involved in generation innovation process exceeded 75% around 58% of them, consider themselves as average innovative persons while 5% perceived themselves as extremely innovative persons.

3.2.1. Individual/ group scale preferences: Modern groups of today differs than hierarchical, insular organizational teams of the past. Crowd-sourcing is the new term for self-organizing, volunteer, democratic groups that form over the web. To have an internet connection, allows anyone around the globe to share a vision and evolve. Smarts and creativity within a team often arise from synergies amongst people with several frames and with various personalities. Groups go through four stages: as forming, norming, storming, performing, and Understanding these natural states help us to ensure team success. Numerically, groups of 5-7 persons and the odd number is preferable to commence an innovative process.[22]

3.2.2. Built- environment scale preferences: Concerning the institutional level, 2.85 out of 5 was the average rating of the surveyed study/work environment as a catalyst for innovation. Not less than

[22] Ness, Roberta B. (2012). ***Innovation Generation: How to Produce Creative and Useful Scientific Ideas***. New York: Oxford UP, Print.

two third of them considered the bureaucratic and rigid managerial and organizational system of their companies as the major reason for lacking innovation-driven work/study environment.

When they were asked about a preferable spatial configuration of work/study environment that fosters innovation, 58% preferred "sea/park view open-plan workspace" as group work area.Oppositely, 42% preferred "isolated study/work nook," 41% preferred "double/triple height informal spaces"(social spaces), 40% preferred parks (out of office) and informal common rooms.35% Responded the question with the choice "home's living room." Unexpectedly, only 11% and 9% considered enclosed open plan office space and cell-type office rooms respectively as suitable places for innovation.

3.2.3. District scale/Immediate context preferences: Almost half of the list preferred the big cities' downtowns as the best location for running innovative businesses. The isolated campus was the least preference (13%). Also, 64% of respondents highlighted that their work/study place is more than 30 minutes driving away from their homes while only 7% live less than 5 minutes' drive away from their work/study places. Meanwhile, a vast majority of the group (86%) indicated that the long daily commuting time affects their innovative capacity in a negative way.

As an immediate context, seventy-five people (58%) prefer having their workplace adjacent to a park or within a waterfront area. Also, sixty-seven participants (52%) claimed that they prefer working on generating innovative ideas while socializing or relaxing in an outdoor area (Ex. Park, outdoor plaza) next to their homes, study place or workspace.

3.2.4. City scale preferences: The findings reveal that more than 50% of the group considered the availability of outdoor green/waterfront spaces as the most important features of the city to attract talented innovators, the Quality of city's Architecture.Moreover, diverse arts and cultural centers (Libraries, Museum, Galleries,..) and Social spaces for connectivity are the highly recommended facilities to be provided in talent grabbing cities.

Also, Between 30% to 49% of the surveyees considered Convention spaces for public dialogue and freedom of expression, Well Renovated historical buildings/areas as points of attraction. Still, Hosting International events (sports, arts, culture,..), high-quality Educational Facilities and Public and ease of transportation system are common factors in attracting talents to the city.

Surprisingly, Indoor entertainment facilities (Malls, Restaurants, Cafes, others), good quality Networking infrastructure and the availability of World Branding multinational companies are perceived as the least magnets within cities for innovators (less than 20%). (Figures 3).

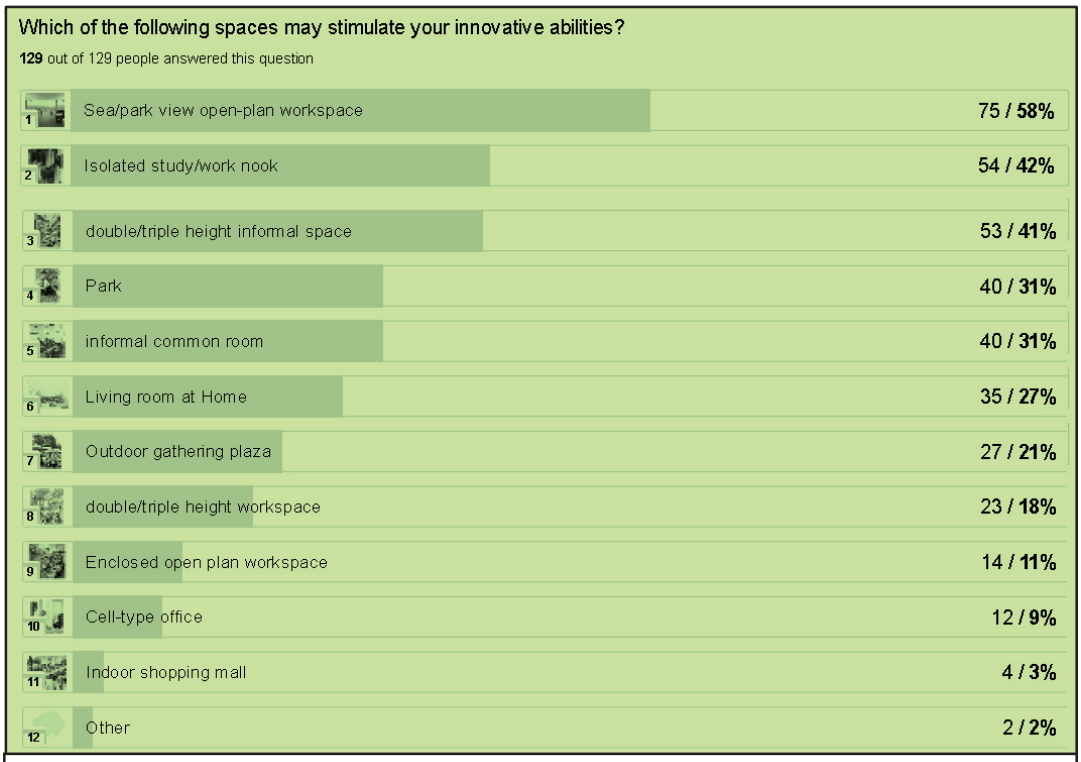

Fig.3 survey results: spaces that stimulate innovation
(Source: Author)

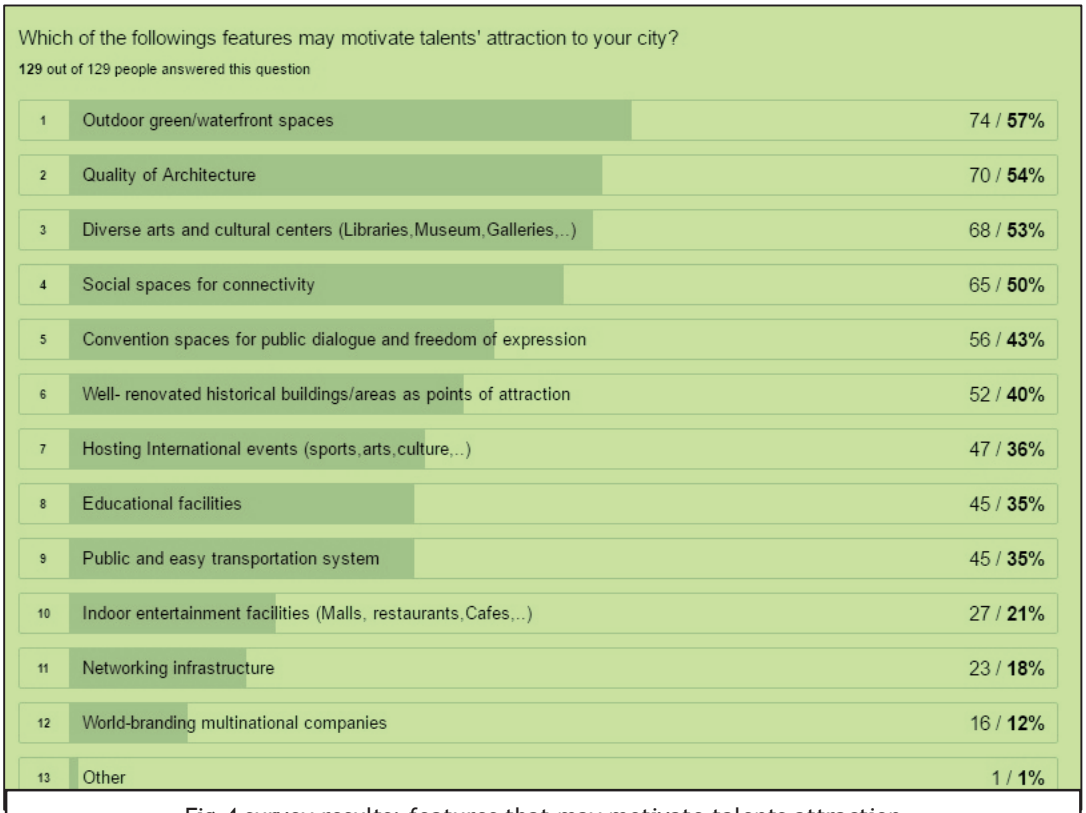

Fig.4 survey results: features that may motivate talents attraction

3.3. Overall Evaluation

When the data collected from the survey are analyzed, it is seen that while the users of open-plan workspace overlooking delightful seaside or park view reveal a high level of satisfaction with their ability of innovation, the same rate is lower for the users of cell-type and enclosed workstations.

The survey outcomes eliminated the cartoonish myth of the incubated genius in a silo to achieve eureka. In brief, socially attractive, informal, personal and outdoor spaced won 199 votes while formal work/study spaces earned 124 votes only.

All survey subjects stated that focus and collaboration are complementary work/live and play modes, and one cannot be immolated in the workplace without directly impacting another; however, in some stages of the innovation process, the enclosed and individualized space is required within an open-plan work/social space. (figure 4)

4. Discussion: Mapping innovation process within time and space:

The surveyed group of architects agreed that innovation in not only limited within the boundaries of the workspace or weekly working hours.Although the innovation generation is considered to by a messy and chaotic process, still it can be framed within a set of stages, techniques, and group's activities.This research is an experimental trial for matching the unexpected dynamic process within a flexible urban, spatial and organizational configuration by following up each stage of innovation and finding the required tools, moods and capacity to be provided in the hosting space of this juncture.

Based on the previous survey and interviewing a group of experts in the field of innovative thinking tools and methods, we drew a road-map that traces the flow of innovation within different environments.

4.1. Innovation as a process:

As a process, innovators and creative workers keep obsessed by their ideas along the day.While relaxing at home, going for shopping, dining in the restaurant, hiking in a park or driving to the office.This shared characteristic of creative class may alter our perception for designing innovative spaces in a dramatic way by considering innovation generation as a continuous process within flexible time frame and suffering among different modes and environments.[23]

Ness states that the process of innovation generation and innovative thinking is messy and risky. If a sudden insight does arise, it is not, as we often assume, that creativity just happens. Instead, it is as Pasteur noted, chance favors the prepared mind.[24]

Figure (5) illustrates the evolution of innovation process within the six steps which are highlighted by Ness's study and shortened in the term "PIG In MuD,"

- **Stage One:" P" stands for Phrase a question**: This stage is mainly concerned with finding the best questions to ask about the mentioned problem. As a process, this needs to be highlighted in assembly setting. Getting unexpected answers, a set of main and sub-question must not be constrained by conventional expectations.
    - The biggest obstacle the innovators face is their preexisting beliefs about the value of gain versus loss; they get stuck in bias rather than being open-minded to the possibility.

[23] Cronheim, C. C. (2004).
[24] Ness, Roberta B.(2012)

- In this stage, formulation group process starts with ***Forming***; Members want to be accepted. They avoid conflict; members begin to figure out what the work entails, but also how they'll fit in.
- The best spatial configuration for this stage is out-of-office gathering space, preferably outdoor area to provide more freedom of thinking and better socializing among the newly assembled team.

- **Stage Two: "I" stands for Identify and break frames**: Identifying frames and finding alternatives is the very foundation of innovative thinking. The main concern is how to come up with a transformational idea and break the frames of traditional thinking?
  - Revolutionary innovation requires breaking the usually embedded and subconscious frames. Also, finding alternative frames can be helped by using metaphors.
  - The innovative team is ***Storming*** after developing trust and feeling freer to challenge each other's opinions. If this grows to consume meeting time, storming can undermine individual motivation and group success. Tolerance, inclusion, and expressing respect are key to getting past perceived conflict.
  - This critical stage takes place within two types of spaces: informal spaces within or adjacent to the workplace and enclosed private or small group meeting spaces.
  - During both stages one and two, the team is highly focusing on finding as much as possible of valuable ideas (Idea centered) within a disruptive mode of innovation.

- **Stage Three: "G" stands for Generate:** at this point, the team is required to filter all available ideas and shortlist a possible one to be transferred into a product. There are many tools for generating and short-listing ideas.
  - ***Norming*** describes the successful maturation of groups that emerge stronger after the storming phase. Trust is established, and the team has gained alignment on aims and plans. The norm and participants become comfortable sharing ideas, no matter how controversial.
  - Spatially, this stage needs more concentration and also diversion along the whole day, not limited to working hours. Thus, social indoor and outdoor spaces, group members' homes and collaborative workspaces are ideal locations for generating, flirting and modifying ideas to be initial products.

- **Stage Four: "I" stand for Incubate:** The successful innovative team uses some tools in breaking frames such as imagination, observation, and analogy. These tools need exceptional spatial configuration and organizational settings to and consider their impact on innovation.
  - ***Performing:*** The group has evolved to allow the expression of frame-breaking ideas. It is now ready to innovate. Teams are autonomous, harmonized, and efficient. As wonderful as this stage is, it is not stable. Which means that team can easily go back to earlier stages of this juncture was mismanaged.
  - In this stage, the proposed product starts being prototyped by consulting external specialists and engineers.
  - Due to the vulnerability of this juncture, all team members should work collaboratively within large size space and private cell-type offices for executing individual tasks.

- **Stage Five- "M" is for melding:** which is merging the best ideas together into a well-engineered product. Move from imagination to implementation. Idea prioritization and development is called convergence. It is an engineering-centered stage when the expense and time are needed to test whether our idea might be true or work makes it impossible to pursue every idea we generate.
    - Also, this stage needs the same spatial setting of stage four, but more individually focused workspace is required for production and detailing.
    - Moreover, the group is in need for large size showroom for testing their product and examining the impression of public opinion.
- **Stage Six- "D" is for Disseminate:** the finally engineered and crafted prototype needs convergence and large –scale testing. Thus, the innovative team needs to commercialize their product and offer it to the community for further development and fine-tuning.
    - Innovative streets, plazas, and parks are ideal centers for revealing innovation.

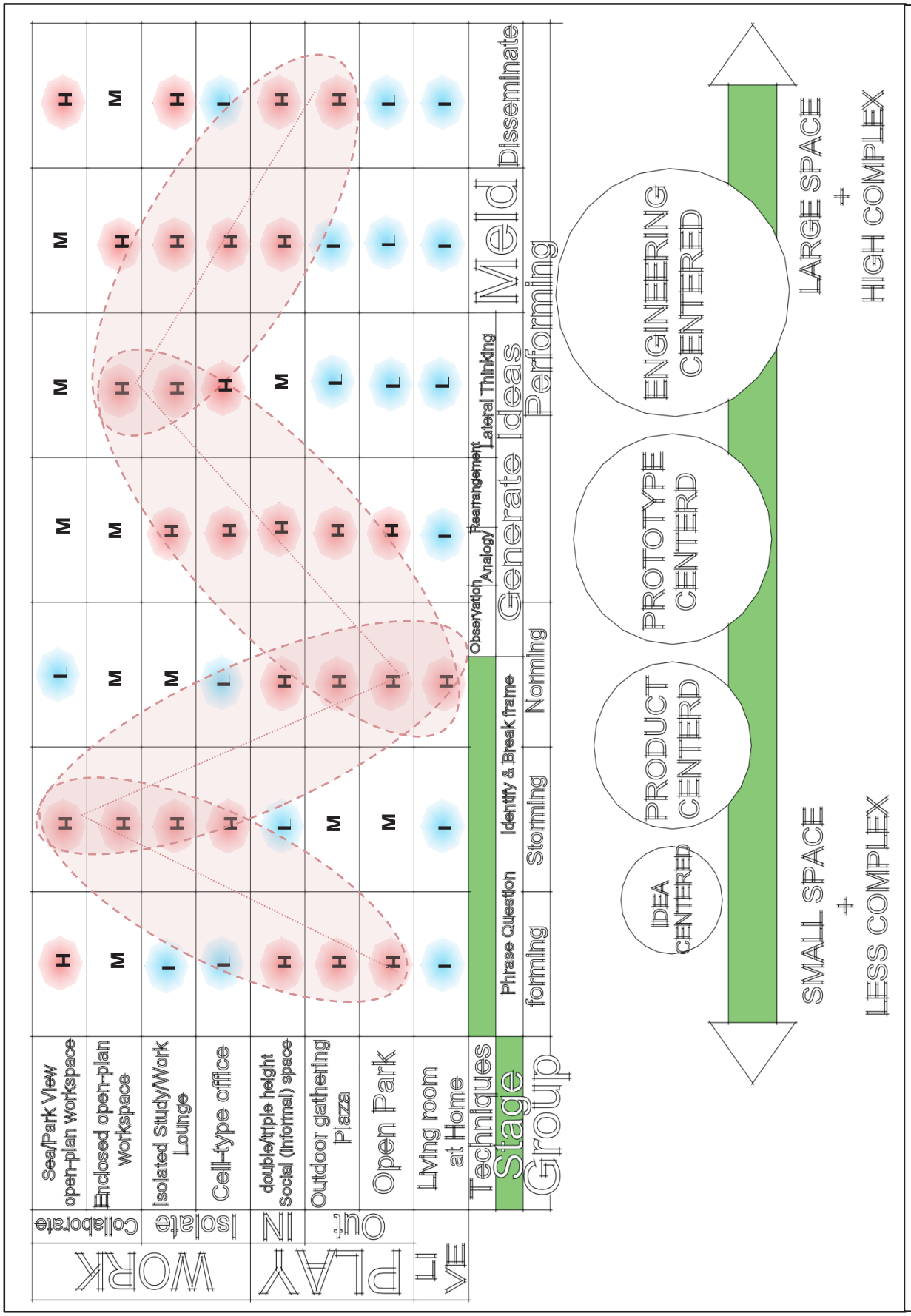

Figure (5): mapping the development of innovation process within different environments.
(source: Author)

4.2. towards a holistic metric for innovative environments:

Referring to the previous map, measuring the capacity of innovation should not be limited to one scale (city, district, building) or one scope (architectural style, space planning, organization,..)it should be perceived holistically within a multi-layered and real-time metric. (figure 6)

The proposed metric reflects the new paradigm of the knowledge-based networked economy to guide innovation policies and illuminate the uncertainties. The architecturally based indicators can be roughly categorized into four interweaving 'pillars', progressively becoming more complex and meaningful as illustrated in **Table 2.**

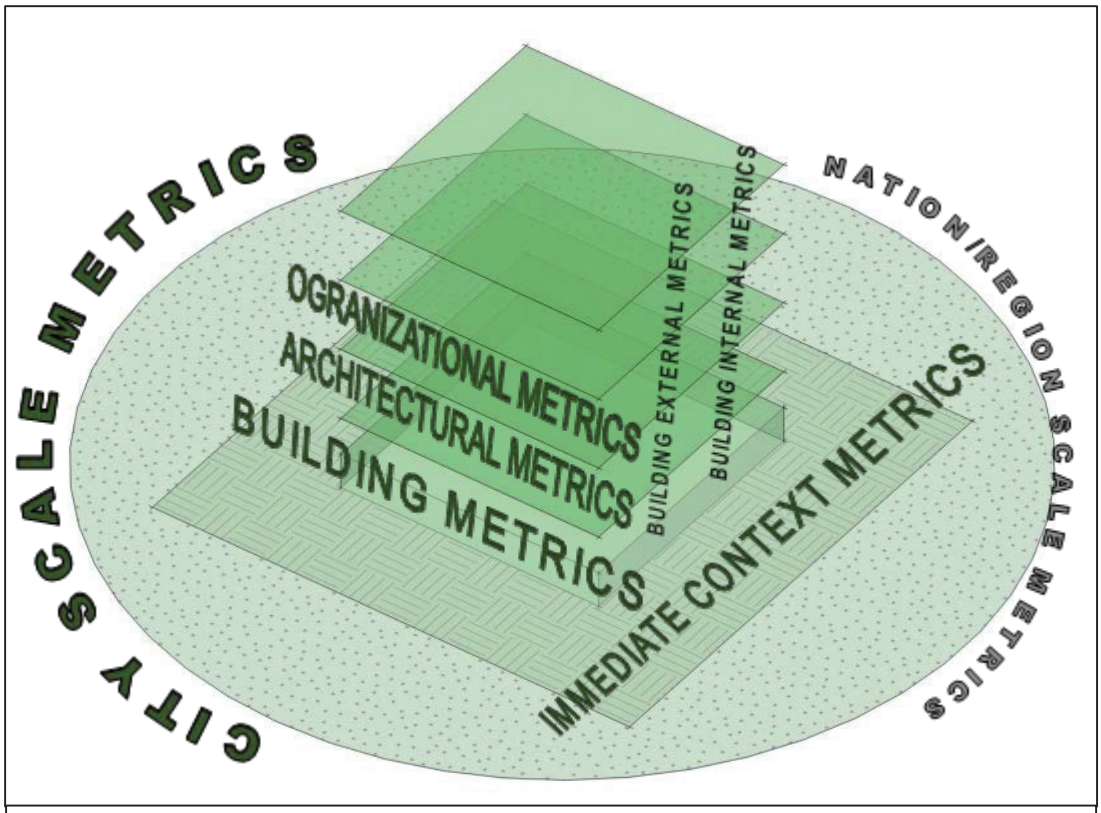

Figure (6) the parameters of innovation ecosystem metric within different environments.
(source: Author)

1. **Spatial parameters**: physical structure and layout of the facilities in which the work is performed, which brings us into the realm of architecture. There are eight spatial indicators to measure the capacity of city, district, building and individual space to host innovation effectively. The mentioned indicators include:
    a. **Compliance (Availability of supporting facilities)**: provide the required support to complete a group of activities.
    b. **The frequency of collaboration**: a shared mind-space that allows positioning individual workspaces around gathering spaces to maximize visibility for all types of communications (3 types). Collaboration can activate through informal brainstorming and information swaps, extensive dialogue with both digital and face-to-face collocation.
    c. **Flexibility (Alone & Together**): a reconfigurable space that supports spontaneity and switching between different work, live and play modes for the further dynamic flow of tools and information. As a spatial solution, flexibility can be done by mixing a group of

fixed and fluid architectural elements, the possibility of re-sizing the space to host small and large groups and considering privacy issues by providing enclosed spaces for audio/visual conferencing.[25]

d. **Reflection of culture and brand(**Showcase & Workspace**)**: spaces have symbolic power, identity and culture provide meaning for innovation. Space can emphasize important local values and processes of this organization by reinforcing tone and cultural authentically within the characteristics of space.The physical configuration of this setting is achievable by displaying local products and achievements to inspire pride and risk-taking culture and by allowing for team customization and personalization of space to reflect ownership and identity.[26]

e. **Inspiration/challenging (Risky & Safe):** space must facilitate the growth and development for those who are charged with product and service creation and development. Also, it should stimulate creative thinking by allowing talents to take risks within a safe, stable environment.this is applicable by providing abundant natural lighting and views, including natural elements and materials within space, careful consideration for color selection and its ability to excite or soothe and providing casual, informal settings.[27]

f. **Social connectivity (internal/external)**: Space must enrich social capital between talented people, either within or outside the organization's boundaries to build trust and sense of engagement within the intense work environment.In the workspace, connectivity exists through convenient access to food and beverages, comfortable social lounges and mingling inviting furniture; social spaces must be located in proximity to both work and community gathering areas around the building/campus.[28]

g. **Continuation(**Designed & Undefined): Keeping the space desirable and evolving as its users over time is an essential attribute for fostering innovation as People prefer familiar and friendly spaces as an emotional and psychological support for them.Moreover, it is considered to be a better financial investment.one of the tools is providing flexible architectural elements and furniture that can easily be reconfigured.

h. Comfort: several attributes can provide comfortable space. One of these is control, which is the ability to make choices as to space's physical form. Also, personalizing the space can provide individual and group control over spaces' contents, boundaries, and experiences. Also, space design and organization should avoid crowding by offering more opening to natural views, higher ceiling and inviting leafier trees to space.

2. Organizational parameters: seemingly, the structure of the formal organization governs the technical communication process among teams and groups within the same organization and other supporting/competing organizations. In the previous section, this study proposed a developed model for "the matrix" model by increasing the layers of interaction and mentoring within and around work environments. Base on the proposed mode in section two of this paper, the attributes of measuring organizational success may include the followings:

a. The efficiency of communication center of gravity: this can be measured by the extent of practicality and novelty of offered ideas, products, services and processes generated by some groups and individuals within this center.

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[25] Steelcase Inc., (2016). ***How Place Fosters Innovation*** . Retrieved May 03, 2016, from https://www.steelcase.com/asia-en/insights/white-papers/place-fosters-innovation

[26] Augustin, S., & Coleman, C. (2012). ***The designer's guide to doing research: Applying knowledge to inform design***. Hoboken, NJ: Wiley.

[27] Coleman, C., Graham, M., & Mulhern, T. (2012).

[28] Augustin, S., & Coleman, C. (2012).

b. **Quality and productivity of knowledge drivers (technical departments):** it can be reported by counting the amount of high quality and state-of-the-art technical support that departments provide to the center of gravity's groups or the teams of the project.
c. **Quality and productivity of market drivers (project-teams):** project teams are responsible for pushing notifications to the center of gravity about the most updated market needs. The capacity and originality of these alarms can measure the quality of this section.

3. **Socio-cultural parameters**: The cultures that constantly produce innovation have visionary leadership, organizational commitment to breakthrough thinking and a place that support the work of innovation[29].Also, socio-cultural shared norms and interests create an informal organizational structure within and between individuals, groups, companies, and regions .this bond which is that develops among any set of people working in the same part of an organization or proximity of one another can act as a charger for innovation. The quality and concreteness of these socio-cultural attributes can be measured by:
   a. **The cultural diversity of local community**: It can be reflected in the productive coexistence of various groups with different linguistic, racial, ethnic, cultural, social and educational backgrounds.[30]
   b. **The average educational level of residences:** highly educated communities can show more tendencies towards socio-cultural interaction. The percentage of college and graduate degree holders from different disciplines (art, science, engineering) can highly enrich the socio-cultural values of their companies, districts, and communities.[31]
   c. **Percentage of the creative class in total population:**[32]
   d. **The density of Public art within lively streets/spots:** by elevating the quality of life, improving the ability to attract more activities, creating an innovation- prized climate and facilitating the marketing of skills and products
   e. **Some Art and culture activities annually (conferences, festivals, exhibitions, shows, concerts..):** It is proven that concentrations of cultural enterprises and creative workers in a geographical area provoke a competitive edge on a range of scales.[33]
   f. **Availability of art and cultural assets (entertainment, education, personal development)**
4. **Technological infrastructure parameters:**
   The dispersion of knowledge has been greatly aided by the ability to communicate information and knowledge via the Internet and by other rapid means. However, these technological tools do not themselves resolve the challenges of managing the innovation process. Thus, technological readiness is densely notable in many nations, regions and cities around the globe, regardless the economic level of development of these communities. The following indicators represent the most influential factors that affect attracting talented innovators worldwide: **Availability of latest technology (products & services), Research and development expenditure (% of GDP), Telecommunication capacity, Capacity of Transportation infrastructure**

[29] Fedorowicz, J. (2001). ***A Review of John Seely Brown and Paul Duguid's The Social Life of Information***. Business and Society Review, 106. http://doi.org/10.1111/0045-3609.00104
[30] Hospers, G.-J. (2006). ***The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community and Everyday Life The Flight of the Creative Class: The New Global Competition for Talent? Richard Florida***. Creativity and Innovation Management, 15.
[31] Micek, G. (2016) ***Understanding innovation in emerging economic spaces: Global and local actors, networks and embeddedness***. Routledge.
[32] Florida, R. (2004). ***The rise of the creative class***. Basic books New York.
[33] David J. (2011), ***How the Arts and Culture Sector Catalyzes Economic Vitality***. Murray American Planning Association

	PARAMETERS	City-Scale	Immediate Urban Context	Building/ Campus-Scale	Individual/ Group-Scale
Spatial Indicators	Compliance (Availability of Supporting facilities)	1X	2X	**5X**	3X
	Frequency of collaboration (3 types of communication)	1X	3X	**5X**	4X
	Flexibility	-	2X	**5X**	4X
	Reflection of culture and brand(contextual)	3X	3X	**5X**	3X
	Inspiration/challenging (hard-working tool)	3X	4X	**5X**	2X
	social connectivity (internal/external)	2X	3X	4X	**5X**
	Continuation	3X	4X	**5X**	2X
	Comfort	2X	3X	**5X**	3X
Organizational Indicators	Efficiency of communication center of gravity	1X	1X	3X	**5X**
	Quality of knowledge driven departments	1X	1X	3X	4X
	Productivity of departments (quantitative)	1X	1X	3X	4X
	Quality of market-driven project teams	1X	1X	3X	4X
	Productivity of project teams (quantitative)	1X	1X	3X	4X
Socio-Cultural Indicators	The cultural diversity of local community	3X	4X	3X	2X
	The average educational level of residences(% of college and post-graduate degrees holders)	2X	3X	4X	**5X**
	% of creative class of total population	2X	3X	4X	**5X**
	Density of Public art within lively streets/spots	3X	4X	**5X**	1X
	Number of annual Art and culture activities (conferences, festivals, exhibitions, shows, concerts..)	4x	3x	3x	2x
	Availability of art and culture assets (entertainment, education, personal development)	**5x**	**5x**	3x	1x
Technological Infrastructure Indicators	Availability of latest technology	3x	4x	**5x**	**5x**
	Research and development expenditure (% of GDP)	2x	3x	4x	3x
	Telecommunication capacity	3x	3x	4x	**5x**
	Capacity of Transportation infrastructure	4x	4x	1x	1x

Table2: Multidimensional metric for evaluating the innovation capacity spaces.
(scale shows 5X= highest relation to 1x lowest relation)
(source: Author)

5. Conclusion:

The primary interest of earlier research was concerned with the regional configurations of innovation cities, how they evolve, flourish and integrate with neighboring regions to generate a network of global-local innovation centers in macro scale. Over time, that interest blossomed to cover the topic of how, when and where exactly innovation thrives in the city. This theme of research is a combination of several approaches and scales: regional innovation systems, urban settings of innovative cities, psychology of innovation and the characteristics of innovative spaces.

As a conclusion, and after analyzing the phenomenon of "Innovation" from different perspectives and within four different scales, this paper is a trial to map and trace the spatial configuration that supports innovation as a process.
More important, this mapping resulted in proposing a multidimensional framework for developing an innovative community.
Also, this research concluded that the readiness of innovation varies dramatically from case to another. what fits a particular type of innovative industry within a specific context may not apply to others. The research set a matrix of horizontal parameters affects innovativeness in different scales (city/region, District/community, Building/Campus and individual/group space).

The most important outcome of this paper is answering the common question from policy makers and stockholders to architects and planners: ***is there an excellent reference or guideline for designing a successful science park or innovation area within a particular spot of our world?***

Still, further justification and testing should take place to enhance the outcomes of the proposed metric. In further research, the findings of this metrics will be aligned with other productivity results for a group of case studies. Some of the most significant cases to be examined are the Crane Building, North Philadelphia. This building is located within a unique, innovative context in Philadelphia's University City (science center). Also, Googolplex is one of the most successful campus-like cases that need to be tested in this metric.

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