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SCIENTIFIC CREATIVITY AND DIVERSITY OF PHYSICAL WORK ENVIRONMENT: FRAMEWORK DEVELOPMENT

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ABSTRACT

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The aim of this research was to develop a framework to analyze how physical environment influences scientific creativity. Due to the relative novelty of this topic, there is still a gap in the unified method to study connection between physical environment and creativity. Therefore, in order to study this issue deeply, the qualitative method was used (interviews and qualitative questionnaire). Scientists (PhD students and senior researchers) of Graduate School of Management were interviewed to build the model and one expert interview was conducted to assess its validity.

The model highlights several dimensions via which physical environment can influence scientific creativity: Comfort, Instruments and Diversity. Comfort and Instruments are considered to be related mostly to productivity, an initial requirement for creativity, while Diversity is the factor responsible for supporting all the stages of scientific creative process. Thus, creative physical environment is not one place by its nature, but an aggregative phenomenon. Due to two levels of analysis, the model is named the two-level model of creative physical environment.

АННОТАЦИЯ

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Целью этого исследования было создание модели для анализа того, как физическая среда влияет на научную креативность. В связи с относительной новизной данной темы, до сих пор не разработан единый метод для изучения связи между физической средой и креативностью. В связи с этим, для того, чтобы детально исследовать этот вопрос, был применен качественный метод (интервью и качественный опрос). Интервью и опрос были проведены с научными работниками (аспирантами и вышестоящими исследователями) Высшей Школы Менеджмента для того, чтобы построить модель; и для оценки пригодности данной модели было проведено дополнительное интервью с экспертом.

В модели подчеркиваются несколько категорий факторов, посредством которых физическая среда может оказывать влияние на научную креативность: Комфорт, Инструменты и Разнообразие. Предполагается, что Комфорт и Инструменты в большей степени относятся к факторам продуктивности и первоначальному требованию для креативности, в то время как Разнообразие – основной фактор, отвечающий за поддержку всех стадий научного креативного процесса. Таким образом, креативная физическая среда – это не единичное место, а совокупная категория. В связи с наличием двух уровней анализа, модель названа двухуровневой моделью креативной физической среды.

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Ekaterina Afanasyeva

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1 INTRODUCTION

1.1 The physical environment in the modern context

The physical environment, how it has been perceived at work and its influence on different aspects of working life (productivity, motivation, creativity, et cetera) has changed over time dramatically. There are still debates about what is the best office layout that will correspond to the current needs of organization: whether it is open plan design or cubicles, or something balanced in terms of private and communal spaces.

Looking at the history, we may consider different stages of how the physical environment has been viewed by management of companies, which is highly connected with the notion of management attitude towards workers (Pitt and Bennett 2008). First distinct stage is the time when the scientific management theory of Frederick Taylor was popular. The workers were viewed as units of production and the physical environment mostly served the purpose of minimizing errors to support the most efficient and effective performance of tasks. This mechanical approach did not take into account such factors as the emotional and psychological atmosphere created by the physical work setting, nor did it view any other advantages of the physical environment except for the possibility to standardize work to achieve the maximum of productivity.

Second epoch is linked with the Hawthorne Experiments, which showed that the physical environment has greater effect on workers than simply influencing their productivity. Examination of how the illumination affects workers' productivity led to a surprising result of changes in workers' behavior not because of the specific changes in the environment, but because of the social factors and motivation. The further development of humanistic approaches in the organizational theory followed these Experiments. However, as Pitt and Bennett (2008) highlight, these Experiments were also a cause of the dominance of social over physical factors in the organizational theory.

Talking about the modern times, companies pay more attention to designing work environment, because now it is seen as a factor influencing many sides of company's performance: employees' motivation and well-being, internal and external image of the company, et cetera. There are even rankings of most creative workspaces. Many high-tech companies are leaders in those rankings, such as Google, Twitter, and Facebook (Smith 2013). This current increase in attention towards the physical aspect of work places is driven by several modern tendencies. According to Jack Bauer's 24/7 routine, people now work whenever and wherever they want. With the current technologies, the office mode of working has changes and people can work from a multitude of places. Companies even struggle to keep their employees in-house due to the reason that creativity is still partly a social phenomenon. Second tendency is the change in workforce. Knowledge workers are seen now as the drivers of company's success and companies try to find ways to adapt to their needs and boost their productivity: creativity and knowledge creation.

New trends in workplace design gain and lose popularity all the time: open plan offices, cubicles, hot-desking and so on. Practical interest drives the theoretical researches on that topic, therefore, the question of the physical environment and its influence on creativity is one of the most cutting-edge topics of the modernity. At the same time, there is still a gap in unified theory connecting physical environment and creativity, which is highlighted by several authors (Kristensen 2004; Sailer 2011) and this research aims to fill this gap. And due to the increasing role of knowledge workers in the workforce, scientists were chosen to be the unit for analysis in this thesis.

1.2 Scientists as a unit of analysis

To explain why scientists were chosen to be the object of this research and the importance of creativity for scientific work, it is necessary to consider two concepts: knowledge workers and creative class.

Considering the widely used taxonomy of workers, there are three main categories: manual workers, knowledge workers and the most brand-new type - innovation workers. Each of them was dominant in the workforce in different periods of time. Manual workers are those who perform their job by hands. Knowledge workers are individuals who are especially valuable for their ability to gather, analyze, interpret, and synthesize information within specific subject areas in order to advance the overall understanding of those areas and allow organizations to make better decisions (Frick and Drucker 2011). Usually knowledge workers are such professionals, such teachers, lawyers, architects, physicians, nurses, engineers, scientists. Also knowledge workers are known for performing non-routine work and for their developed cognitive skills. The innovation worker is a new term not common in the literature yet, but this term is gaining more and more popularity. The innovation worker is, in some sense, the next version of knowledge worker. As companies need to be more and more innovative in order to survive in a highly competitive environment, not the usage of available information, but the ability to create something brand-new on the basis of this information is becoming more relevant. Some scientists say that the innovation worker is just a type of knowledge worker (Maruta 2012), some scientists combine these two notions into one – an innovation knowledge worker (Lawrence 2009), and some describe the innovation worker as a new type of worker in a company, "whose creativity, agility and commitment to continuous learning will drive future economic growth and lead to the next generation of ideas and inventions that shape our lives" (Intrepid Learning Solutions 2012, 1).

As long as the concept of the innovation worker is not established yet, scientists are analyzed as knowledge workers in this research. Knowledge workers and creativity are related on several levels. First, the product of knowledge workers' activity is new ideas. According to Henard and McFadyen (2008), the creative capability of individual and collective knowledge workers is the fuel that drives a company's engine of innovation. And they even argue that there are several capabilities of knowledge workers to deal with such a multifaceted resource as knowledge. There are three types of knowledge: acquired, unique and creative, with the creative knowledge being the peak of an individual's knowledge

capability. Creative knowledge implies not only production of new ideas from connection of different sources of information, but it is more about new-to-the-world idea for which no previous solution existed. Therefore, the job of knowledge workers is creative in its nature. Secondly, one of the indicators of knowledge workers' performance and productivity is innovation/creativity specified as "the ability of creating new and ideas to improve productivity" (Ramirez and Nembhard 2004, 617). Thus, creativity is an integral component of knowledge workers' job to achieve their tasks.

Talking specifically about researchers, they can also be attributed to the creative class. Following the definition of Florida (2002), the creative class engages in work, the function of which is creation of meaningful new forms. This creative class includes scientists, university professors, poet and architects, and a diverse group of other creative professionals (Lorenz and Lundvall 2010). This group is, therefore, even narrower that the notion of knowledge workers, but still it justifies our unit of analysis in this research because of its high connection to creativity and creative work.

Many other authors study creativity in its connection to knowledge work as well (Martens 2011; Dul, Ceylan and Jaspers 2011). However, only a limited number of researches are devoted to scientific creativity. Parkin et al. (2011) focuses the research on studying the issue of balance of collaboration and privacy in the academic workspaces, but other physical factors are not discussed in detail or even omitted. Walsh, Anders and Hancock (2012) are mostly concentrated on attitudes of researchers towards creativity and only slightly mention the role of physical environment for scientific creativity. Bisadi, Mozaffar and Hosseini (2012) also study only few characteristics of the physical work space – privacy, beauty, spatial diversity and proximity. Thus, the research on connection between scientific creativity and physical work environment is quite fragmented and needs further investigation, which is done in this thesis.

1.3 Research questions and objectives

As it was shown in the previous sub-chapters, the topic of this Master's thesis is in high demand both from the theoretical and practical points of views. And as long as this research is exploratory; first and foremost, the focus is made on answering some general questions, which still have not been answered. The main and central research question is as follows: *how to assess physical work environment in its connection to scientific creativity?*

The sub-questions that need to be answered throughout the study to accomplish its goal are:

- What elements of the physical environment have most influence on scientific creativity?
- Which models of physical environment have been used so far to analyze its effect on scientific creativity?
- Does physical environment have strong connections to creative climate and can it be studied from this symbolic perspective?

The answers to the main question and sub-questions will be formulated upon achieving the following objectives of this research:

- To identify the aspects of the physical environment related to creativity of researchers,
- To identify the elements of the creative climate, which can be conveyed by physical artifacts and environment,
- To find out which physical artifacts are related to which elements of the creative climate.

1.4 Research structure

The structure of this Master's thesis follows the established standards of scientific reporting. The thesis is divided into 5 chapters. The first chapter – Introduction- serves the purpose to explain to a reader the background and topicality of this

research and to clearly state the research question and theoretical framework so that the reader can follow the logic of this research more easily.

The second chapter provides a reader with a detailed analysis of theoretical concepts related to this research. The theoretical models are presented and compared; in the end, the summary table of physical characteristics connected to creativity is provided. The theoretical models and a list of physical characteristics are also the foundation for empirical data collection and the design of questionnaire and interviews.

The third chapter provides description of research methodology, in general, and the particular methodology used in this research with a thorough explanation of reasoning behind the choice of methods and how they were exploited in this work. The research methodology is explained not only in its relation to primary data, but methods of secondary data collection are also explained and concluded with a fish-bone diagram explicitly stating the theoretical concepts used in this thesis.

The forth chapter is devoted to analysis of empirical findings both from the questionnaire and interviews. This chapter is further divided into the themes and sub-questions which are stated previously, which allows to follow the discussion more easily and to find answers to particular research questions.

The last chapter serves as a summary of both theoretical and empirical analysis and clearly states the answers to the outlined research question and sub-questions. In this part, limitations and suggestion for future research are also discussed.

1.5 Theoretical framework

Theoretical framework depicts the main theoretical approach with which the research is performed denoting central concepts and terminology. Theoretical framework allows a reader to understand the logic of the research and, thus, enhances the understanding of the whole research. Theoretical framework of this Master’s thesis is presented in Figure 1.

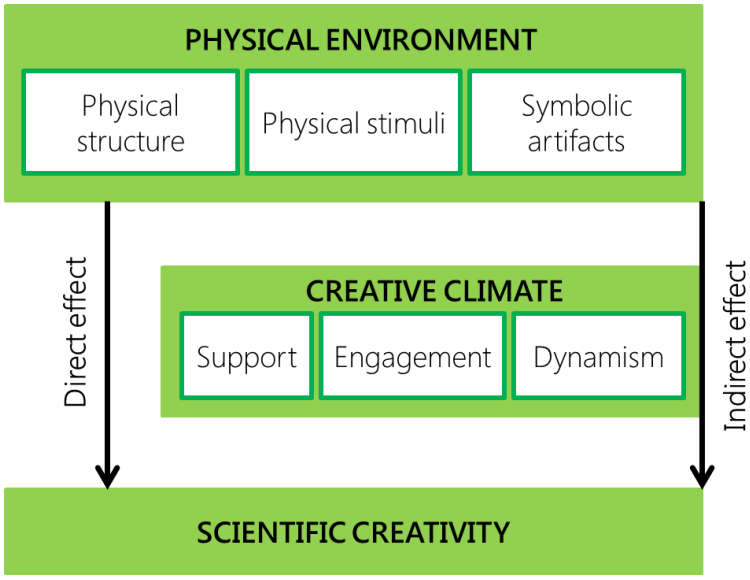

Figure 1: Theoretical framework of Master's thesis

Physical work environment can be represented via separate physical artifacts, which, in turn, may be grouped into three categories: physical structure, physical stimuli and symbolic artifacts (Davis 1984). However, despite the terminology, each of these physical artifacts can convey a symbolic meaning to the employees of an organization (Kristensen 2004; Moultirie et al. 2007; Haner 2005). This meaning can be analyzed through the concept of creative climate and a model of Ekvall (1996), in particular. The elements of this model are divided into such components as Support, Engagement and Dynamism. Different physical artifacts can support one or several components of the creative climate, and by enhancing the creative climate inside an organization, they affect scientific creativity. At the same time, all these physical artifacts or characteristics of physical environment can influence researcher's creativity directly (Dul and Ceylan 2011; McCoy and Evans 2002), which is represented by the first arrow going from the box "Physical environment" to the box "Scientific creativity".

2 CREATIVITY AND PHYSICAL ENVIRONMENT: THEORETICAL PERSPECTIVE

In this chapter, theoretical concepts related to creativity and physical environment are explored in detail. First, the definitions of creativity and scientific creativity are identified. The issue of physical artifacts and how they can serve as symbols representing creative climate is discussed. Approaches to connect physical environment and creativity are presented and compared. The summary table of all the found physical characteristics influencing creativity is provided at the end of the chapter.

2.1 Creativity: its definition and distinction from innovation

Creativity is a widely used and popular concept in the modern world. There are many discussions on the Internet about how to be creative. However, in the scientific circles studies of creativity are not at the advanced level, which can be a result of scientific aversion to this topic because of its high degree of romanticism and mysticism (Walsh, Anders and Hancock 2012). The concept of creativity is often used in conjunction with the concept of innovation. Therefore, the clear definition of creativity is necessary to understand this phenomenon and to see the distinction between creativity and innovation.

Walsh, Anders and Hancock (2012) identified several common ways of defining creativity:

- Creativity as a result of personality traits.

This definition is mostly used in in the field of psychology; the greater accent is made on the individual level of creativity as a specific capability of a person to create new ideas. But the similar approach may be noticed in encyclopedias. In most dictionaries, the definition of creativity is given only considering its individual aspect. According to Oxford Dictionary, creativity is the use of imagination or original ideas to create something; inventiveness. While according to Merriam Webster dictionary, creativity is seen as the quality of being creative

and the ability to create. Encyclopedia Britannica has a similar definition of creativity: "the ability to make or otherwise bring into existence something new, whether a new solution to a problem, a new method or device, or a new artistic object or form".

- Creativity as behavior: process.

The widely excepted description of creativity as a process belongs to Wallas (1926). He views creativity as a series of stages: preparation, incubation, illumination and verification. Preparation means preliminary analysis, definition and identification of a problem, incubation is a period of non-conscious mental work on the problem, illumination is when an idea (solution) to the problem is found, which is followed by verification – conscious mental work, which involves evaluation, refinement and development of the idea. As it is noticed by Lubart (2010), there have been a lot of suggestions to modify this basic four-stage model of the creative process, but currently this model is one most used and accepted by the academia.

- Creativity as behavior: skill set.

“At the narrow end of the spectrum of creativity as behavior is the idea of creativity as simply a set of skills, heuristics or techniques” (Walsh, Anders and Hancock 2012, 22). The view on creativity as a set of skills that can be learned gave birth to development and popularization of such concepts as brainstorming, mind-mapping, six thinking hats, et cetera. Here it is worth mentioning the current distinction between Big-C creativity (which belongs to the works of “geniuses”) and small-c creativity, which happens every day and on a smaller scale (Craft 2001). Kauffman and Beghetto (2009) added new levels of creativity which resulted in the four C model of creativity: mini-c – the concept of creativity as intrapersonal insights and interpretations; and Pro-c creativity - “developmental and effortful progression beyond little-c” (Kauffman and Beghetto 2009, 1) in the professional area of activity. Therefore, when talking about last three categories of

creativity, it is natural to talk about creativity training to enhance this human capability.

- Creativity as a product.

To define creativity as a product, many authors use the following definition developed by Amabile (1997). According to her definition, creativity is the process of bringing into being something that is both new and useful. So creativity embraces two components, which are novelty and usefulness. From this definition, we may extract two features which are important to understand the notion of creativity. First of all, creativity is related to something new: new product, new service, new solution and so on. Secondly, creativity is related to some cognitive skills, it is something new in the context of solving some particular task. Thus, creative people not only come up with novel ideas, but these ideas should have a link with the current goals or purposes so that to be called useful. NACCCE (the National Advisory Committee on Creative and Cultural Education) also outlines the same features of creativity: "creativity is an imaginative activity fashioned so as to produce outcomes that are both original and of value" (NACCCE 1999, 30).

- Creativity as a function of the environment.

First, the first distinction is drawn between different levels of creativity: individual, group and organizational level. And secondly, on the organizational level, factors of the environment conducive to creativity are identified. In this vein, the definition of organizational creativity is important to consider and Woodman and Griffin (1993, 293) define it as "the creation of a valuable, useful new product, service, idea, procedure or process by individuals working within a complex social organization". Thus, the interactionist perspective on creativity and its social side is highlighted, increasing the number of influencing factors to include more external parameters.

These different definitions of creativity are justified because of complexity of the phenomenon and, furthermore, in their research Walsh, Anders and

Hancock (2012) found out that researchers themselves define creativity in different ways, which led them to a conclusion that “there is arguably little point in seeking to agree and work with a universal definition of creativity” (Walsh, Anders and Hancock 2012 31).

Furthermore, these approaches are echoed by some other authors, though not very explicitly. According to the Componential Theory of Creativity by Amabile (1997), the influencers on creativity include three within-individual components (domain-relevant skills, creativity-relevant processes and task motivation), the outside component (the work environment, or more generally, the social environment) and team-related components (resources in task domain, skills in innovation management, motivation to innovate). So here not only two different level of analysis are mentioned (which are individual and group creativity), but also the aforementioned approaches can be traced: creativity from the point of view of personality traits, process and function of the environment. Or considering other widely used theory on creativity called 4P by Rhodes (1961), creativity is viewed via the prism of four determinants: person, process, press and product. The cognitive process of creativity starts in the minds of individuals (Garfield 2008); thus, the notion of person includes individual traits, skills, intrinsic motivators, group diversity, leadership, et cetera. Process is techniques deployed to focus and enhance creativity. Press is “the context in which creative ideas are produced and explored” (Garfield 2008, 745). Product is the outcome received from the creative process, creativity of its product can be measured according to different characteristics. Therefore, creativity is described using almost the same terms in this model as well.

To clarify the definition of creativity even further, it is also useful to compare it to the notion of innovation at different angles of analysis. In some papers, it is even possible to see the definition of creativity given via the term of innovation only. These definitions clearly describe deep interrelation and interconnection of creativity and innovation. “Creativity is the raw material of innovation. On the other hand, innovation is creativity implemented” (IBM Institute for Business Value 2010, 2). It is essential to understand the relation between creativity and

innovation from the very start, because more and more companies pay attention to being innovative in our innovation-driven world, and thus, it is important for them to be creative as well. For example, UNCTAD identifies economic creativity as a process that leads to innovation in different fields: technology, business practices, marketing and so on and as a factor of achieving competitive advantages in the modern economy (UNCTAD 2010). Therefore, creativity may be seen as a first stage to bring innovations into economy.

Creativity and innovation can be compared on different levels. First of all, considering results, creativity is seen as production of new and useful ideas, while innovation is successful implementation of these ideas. In terms of process, creativity is a seed for innovation, while innovation may or may not follow the creative process. In terms of agents, creativity is more likely to emerge on the individual level, while innovation is attributed to the overall organizational level.

The last issue which is essential to consider when studying creativity is its nature in terms of outcomes. Kampylus and Valtanen (2010) state that scientific research on creativity has mainly been focused only on the positive side of creativity, thus, neglecting some negative consequences of this phenomenon. In the organizational context, negative side of creativity can be expressed through such issues as the breaking of rule and standard operating procedures; the challenging of authority and avoiding of tradition; creation of conflict, competition and stress; and the taking of unnecessary risk (Kampylus and Valtanen 2010). And even though this malevolent creativity may take place in organizations from time to time, in our research the focus is made on the positive side of creativity which needs stimulation from the environment external for an individual.

Concluding this definition analysis, this thesis follows the understanding of creativity as a derivative from the environment. However, there are multiple legitimate definitions of creativity, which simply put more emphasis on various aspects of the complex issue called creativity. One definition which summarizes well the multiple facets of creativity and which is applicable in this research was found in the work of Bisadi, Mozaffar and Hosseini (2012, 233): “creativity is the

interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context".

2.2 Scientific creativity

As it was already shown, creativity is a multidimensional notion that makes it difficult to give a single uniform definition of this phenomenon. And what makes this notion even more complicated is its specificity to the professional context. Although creativity is perceived as a general characteristic and a people's skill, different jobs describe creativity in various terms. This distinction is highlighted by numerous studies which compare so-called artistic and scientific creativity (Perrine and Brodersen 2005; Charyton and Snelbecker 2007). The interest towards these types of creativity is explained by the widely excepted fact that the arts and science are two domains which are highly dependent upon the creative process (Perrine and Brodersen 2005).

Two most used definitions of scientific creativity are as follows:

"Scientific creativity is an individual and social capacities for solving complex scientific and technical problems in an innovative and productive way" (Heller 2007, 209).

"Scientific creativity is the process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypothesis about the deficiencies; testing and retesting these hypothesis and possibly modifying and retesting them; and finally communicating the results" (Liu, Lin 2013, 3).

Although these definitions provide a clear understanding of scientific creativity, they do not show the complexity of the issue under investigation. These definitions put emphasis only on one or other aspect of scientific creativity: in the first case – on creative skills and in the second case – on the process defining

creativity as a detailed step-to-step phenomenon. The 4P model of Rhodes (1961) can be utilized to analyze scientific creativity – the model which was first applied in defining general creativity. There have been attempts to analyze scientific creativity in the same vein by several authors – Hu and Adey (2002) who constructed three-dimensional model which includes three components – process, product and person; but it leaves out environment or press, because, according to authors, it was not applicable in their analysis. Stumpf (1995) also analyzed four aspects of creativity: product, process, person and creative situation. Although the approach of Stumpf (1995) was also based on the model of Rhodes (1961), the interpretation of the fourth component is different in this research; it is seen not only as a situational factor (Zeitgeist in the words of Stumpf), but as a wider concept of the environment.

There are some specifics of a product related to scientific creativity. First of all, it is possible to distinguish different creative outputs of scientific work (turn to Table 1), which includes not only new ideas or discoveries, but also an invention of new instruments for analysis (Heinze et al. 2009). A different approach to view scientific products is encountered in Hu and Adey (2002) and the products are divided into the following categories: technical products, advances in science knowledge, understanding of scientific phenomena, and scientific problem solving. Secondly, in terms of evaluation of novelty and originality of scientific products, the scientific product also ranges considerably: from citation index used for evaluation of scientific papers to prizes (such as the Nobel Prize), and to patents and certificates (Heinze et al. 2009; Simonton 2009; Rothenberg 1996; Park, Lubinski and Benbow 2008). Some criticism is given to these forms of evaluating scientific creativity. For example, from the point of view of Frederiksen, Evans and Ward (1975), these peer-based measures may show not creativity of scientists, but their promotion skills. However, as long as this thesis does not attempt to provide typology of all possible scientific achievements, but it rather aims to show how scientific product varies in its context, which is an obvious conclusion from this paragraph.

Table 1: Typology of scientific creativity (Heinze et al. 2009)

Type of scientific creativity		Examples
1.	Formulation of new ideas (or set of new ideas) that open up a new cognitive frame or brings theoretical claims to a new level of sophistication	Theory of specific relativity in physics (EINSTEIN, 1905)
2.	Discovery of new empirical phenomena that stimulated new theorizing	Biodiscovery → Theory of evolution (Biology), DARWIN (1859)
3.	Development of a new methodology, by means of which theoretical problems could be empirically tested	Factor analysis → Theory on mental abilities (Psychology), SPEARMAN (1904a, 1904b, 1927)
4.	Invention of novel instruments that opened up new search perspectives and research domains	Scanning tunneling microscopy → Nanotechnology (Physics), BINNIG & ROHRER (1982)
5.	New synthesis of formerly dispersed existing ideas into general theoretical laws enabling analyses of diverse phenomena within a common cognitive frame	General systems theory (Biology, Cybernetics, Sociology), BERTALANFFY (1949), ASHBY (1956), LUHMANN (1984)

Turning to the next component of scientific creativity - a person, different resources highlight different attributes of scientists' personalities which make them more or less creative. But most of them correlate with the usual attributes used to describe creative people in general. What is more important in the scientific realm is the question of intelligence and domain-specificity of creativity. The importance of domain-specificity is highlighted in several sources (Simonton 2009; Hu and Adey 2002) and this feature was explicitly mentioned in one of the most accepted models of creativity by Amabile (1997). In this sense, Charyton and Snelbecker (2007) conducted an interesting study to evaluate general, artistic and scientific creativity of music and engineering students. While usual methods of assessing a creative personality were used, such as Creative personality scale or Cognitive risk tolerance survey; distinct tests specified to a particular profession were applied to evaluate specific types of creativity –

Harmonic improvisation readiness record for evaluating artistic creativity and Purdue creativity test for evaluating creativity of engineers. The results show low correlation between artistic and general creativity and the same holds true for the correlation between scientific and general creativity. These results prove the necessity to emphasize the domain specificity of creativity even more, especially when studying different professional groups and their creative behavior. As for intelligence and creativity among scientists, this puzzle has been known for many years and it is most vividly stated by Edison's famous quote: invention is 1% inspiration and 99% perspiration. The answer to this question is still ambiguous and the results of research show different patterns (Park, Lubinski and Benbow 2008), though going back to the Componential Theory of Creativity by Amabile (1997), knowledge has always been stated as an important component influencing creativity of all people.

When considering scientific creativity, there is one more interesting fact about the scientific creative person: scientists do not lie far away from being seen as artists as well. The art is more important to science than it seems on the surface. One great distinction between artistic and scientific creativity is that artists create so-called subjective knowledge, while scientists' work is concentrated on acquiring objective knowledge. However, the form of presenting this knowledge shows that artistic and scientific creativities are not completely different. The importance of beauty in science is highlighted by Carafoli (2009), who gives examples of elegancy of DNA helix and the golden ratio that is used both in music and mathematics. This view is also articulated in other studies: "scientific creators are those who are artistically creative rather than those who rely heavily on deliberate and deductive logic" (Simonton 2009, 447). Therefore, the conclusion that shall be drawn in this case is that not only scientific creativity and intelligence per se, but also general and artistic creativities are also important for scientists.

There are also some peculiarities of scientific creativity in terms of process. While creativity is usually associated with divergent thinking, scientific work includes not only this type of thinking, but also a significant part of convergent thinking (Heller 2007). Divergent thinking is used at the beginning of solving problems

and devising possible solutions, while convergent thinking is thought to be employed by scientists when formulating hypotheses. This essential step of scientific work as formulating hypotheses was even proposed to be used as a test for scientific creativity (Frederiksen, Evans and Ward 1975) in so-called the Formulating Hypothesis test.

Considering the last element of creativity – press, or in other terms, environment, this issue is still ambiguous in its implementation to scientific creativity. While some authors (Heller 2007) mention "creative learning environment", which is connected more to the social component of the environment, others (Stumpf 1995) highlight more situational context of this phenomenon using the notion of Zeitgeist (historical perspective). The situational approach to the environment may be detected in the work of Heller (2007) as well, where such elements as current information/knowledge state, practical necessities for operational companies, economic, societal and ecological perspectives are mentioned among factors. In other sources (Heinze et al. 2009), physical aspect of the environment is mentioned to influence scientific creativity, but without much detail. As long as the exposure to broader knowledge is thought to provoke creative thoughts, special arrangements that serve to connect different scientific departments are viewed as a factor conducive to scientific creativity. Besides the abovementioned features, there was not found a more thorough analysis of the environment and its connection to scientific creativity.

In the context of analyzing scientific creativity through the prism of its four constituents, a study by Walsh, Anders and Hancock (2012) show interesting results. This study was partially attempted to understand how STEM researchers define creativity. The most widespread understanding of creativity was as a process, but the act of defining creativity was problematic and some researchers viewed it as a negative rather than positive phenomenon.

In the end, scientific creativity fits the general pattern of analyzing creativity, although it obviously has some distinct peculiarities. This fact does not necessitate defining scientific creativity in a different from general creativity manner.

Therefore, it was chosen to view scientific creativity in the same terms as general creativity in this thesis, but to keep in mind specific features of scientific creativity.

2.3 Symbolism of physical artifacts

Artifacts are usually analyzed in their connection to organizational culture and, thus, they are often called cultural artifacts. Organizational culture is "the pattern of basic assumptions that a given group has invented, discovered, or developed in learning to cope with its problems of external adaptation and internal integration, and that have worked well enough to be considered valid, and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems" (Schein 1990, 111). In other words, organizational culture can be explained with the following motto: the way we do things around here.

Schein's model describes several layers of organizational culture, which are: basic underlying assumptions, espoused values and artifacts (Bjerke, Ind and De Paoli 2007). The most visible component of the organizational culture is artifacts, which serve the purpose to express this culture in an apparent manner. Although when describing the organizational culture that stimulates creativity and innovation, Martins (2003) brings to the front the following determinants: strategy, structure, support mechanisms, behaviors that encourage innovation, communication. And it seems impossible to draw connections between these elements and their symbolic meaning (representation of values and norms of an organization). Therefore, artifacts can also be discussed in connection to the organizational climate, in general, and to the creative climate formulated by Ekvall (1996), in particular, which is done in the next sub-chapter.

According to Stigliani (2008), organizational artifacts are generally overlooked and underexplored in their connection to creativity. And in her recent study, Stigliani (2008) drew an explicit connection between cultural artifacts and creativity exploring the importance and role of artifacts at different stages of creative process: generation of ideas, evaluation and refinement, internal sharing

and external alignment. But this study is concerned with all cultural artifacts, while the object of interest in this study is the physical work environment and physical artifacts particularly.

By analyzing categorization of artifacts, the physical surroundings were proposed to be seen as artifacts in the paper of Higgins and Mcallaster (2002) as the fifth components to the model of Shrivastava which identifies the following artifacts: myths and sagas; language systems and metaphors; symbols; ceremonies and rituals; identifiable value systems and behavioral norms. Considering other classification, physical artifacts follow under the category of "the material expressions" in Bang's classification of artifacts' dimensions: behavioral expressions (actions, behaviors), verbal expression stories (myths, language), material expressions (objects, physical structure and architecture) and structural expressions (ceremonies, rituals) (Bjerke, Ind and De Paoli 2007). According to Gagliardi (1996), an artifact is seen as the material and physical environment that organizational members ascribe meaning to. However, the authors continue on saying that the cultural aspect of this attribute is better to be categorized as the values and norms held in the culture about its physical surroundings, which takes us back to the notion of values and norms. This idea is supported by Hogan and Coote (2013) who say that the physical environment serves not only instrumental, but symbolic and aesthetics function and that office design and décor may symbolize a social order in an organization. Moreover, the physical layout of an organization has an impact on valued and expected behaviors. For instance, different office layout may facilitate or hinder the communication and collaboration between different employees. Higgins and McCallaster (2002) analyzed the physical surroundings as a type of cultural artifacts important to stimulate innovation only through the prism of office layout ("to cubicle or not to cubicle"). However, there are many more aspects of the physical environment related to creativity and innovation and the layout is only one of many physical characteristics which can be studied from this perspective. And when identifying physical environment as an artifact, Hogan and Coote (2013) measured it with two statements, which deal only with the spatial layout of the office, but not other physical components. The statements were formulated in the following way:

1. There are meeting areas and discussion rooms within our firm where employees can meet to discuss new ideas and ways to implement them.

2. We have set aside space within our office layout where employees can meet and talk informally about new ideas and novel ways to solve problems (Hogan and Coote 2013).

Furthermore, when studying the physical work environment as a symbolic artifact, the authors noted that it can convey different meanings at the same time. For example, an organization that wants to promote a sense of equality among personnel will avoid using visible status symbols, such as “extravagant offices for senior managers” (Hogan and Coote 2013, 5) or if an organization wants to promote collaboration and open communication among employees, it can be facilitated via office layout. This emphasizes the complexity of signals produced by the physical artifacts and multi-sidedness of this question.

In the work of Brooks and Gaalema (2012), where the physical artifacts were analyzed in their relation to campus tours and symbolic messages received by potential students, more attention is paid to the symbolic aspect of the physical structures and this aspect is further divided into these components: fixed, semi-fixed and non-fixed environmental elements. Fixed elements are the physical structures itself, such as walls, ceilings and floors. Semi-fixed elements possess a certain level of flexibility: furniture and pictures. And non-fixed elements are people, which are ever-changing part of the physical space. The authors concentrate on analyzing fixed and semi-fixed components in their work as those that “are particularly capable of conveying messages about culture” (Brooks and Gaalema 2012, 56). This fact highlights the possibility and necessity to study not only fixed physical components of space (such as layout), but other semi-fixed aspects which can also serve as symbols of organizational culture or climate.

There is a pattern to study physical cultural artifacts through the following triangle: instrumentality (the extent to which the artifact contributes to performance or to promoting goals), aesthetics (sensory experience provoked by

the artifact and the extent to which this experience fits individual goals and spirit) and symbolism (symbolic meaning which is concealed in the physical environment) (Rafaeli and Vilnai-Yavetz 2004). In the similar vein, the model of Carnevali (1992) which analyses the effects of objective physical factors on individual attitudes and behavior, and organizational productivity, may be interpreted. The dimensions of this work – adequacy, arrangement, symbolic features and control – highlight such roles of the physical environment as instrumentality and symbolism. As for the aesthetic component, it was studied even separately and it was found that employees "become more creative in a nice physical environment because they produce better solutions for their customers" (Bjerke, Ind and De Paoli 2007, 66).

Although there was a research to identify how physical artifacts are related to different aspects of a company's performance (Bjerke, Ind and De Paoli 2007), and some authors state that management of cultural artifacts (including physical surroundings) is a vital components of spurring innovation in an organization even on the strategical level (Higgins and McCallaster 2002); there is an existing lack in identifying particular artifacts related to creative performance of an organization and individuals. Moreover, there is a tendency among authors (Hogan and Coote 2013) to study the relation between physical artifacts and creativity in a very narrow manner (by analyzing office layout only). So there is an obvious gap in studying physical artifacts in relation to creative climate.

2.4 Creative climate as a foundation for analyzing physical artifacts

Artifacts can convey symbolic meaning to employees of an organization, which, in turn, will influence their creativity. Symbols are related to human perceptions and, thus, can be discussed through the prism of organizational climate or culture. As it was stated previously, analysis of physical artifacts is done via its relation to organizational climate of creativity in this thesis. The concepts of organizational climate and culture of creativity shall be clearly defined to draw the distinction between these notions so that to choose the most appropriate one for analysis of physical environment.

First of all, specifying the different types of creativity within an organization, several authors (Amabile 1997; Woodman and Griffin 1993) agree that there are three distinct level of creativity: individual creativity, group creativity and organizational creativity and every level has its specific determinants. Individual creativity is often associated with personality and cognitive factors, intrinsic motivation and knowledge; while group creativity is determined by such factors as group composition, group characteristics, group process factors (Woodman and Griffin 1993). Oftentimes leadership (especially, transformational one) is examined as an additional component influencing employees' creativity (Cheung and Wong 2011).

The traditional model of organizational creativity by Woodman and Griffin (1993) implies that there is a multitude of factors influencing creativity. Among these factors are organizational climate, organizational culture, leadership style, resources and skills, structure and systems (Andriopoulos 2001). Two main approaches to study organizational creativity via its climate conducive to creativity and innovation are found in the works of Amabile (1997) and Ekvall (1996). These two approaches are the ones most used in the research related to evaluating environment for creativity in organizations (Moultrie and Young 2009).

However, before examining these two models, it is essential to emphasize that usually organizational creativity is analyzed in accordance with the creative climate and not with the creative culture. There is an ongoing debate about the usage of two terms: climate and culture. Organizational climate deals mostly with such terms as "atmosphere" or "mood"; while culture is concerned with basic values, assumptions and beliefs shared in an organization and manifested via actions. In this sense, such categories as participation, freedom of expression are used in connection to climate, and such categories as risk-taking, trust and respect for the individual are used to describe culture (Andriopoulos 2001).

Usually, the distraction which is drawn between these two concepts is that climate is "observed and recurring patterns of behavior, attitudes, and feelings that

characterize life in the organization" (Isaksen and Akkermans 2011, 165), and, therefore, more visible and measurable than culture, which refers to a deeper level of organization psychological and behavioral patterns, such as values and beliefs (Isaksen et al. 2000 – 2001). Still, these categories are intertwined and some authors combine them into a singular concept of "culture and climate" when speaking about its effect on creativity. Thus, the concepts of creative climate and creative culture need detailed clarification, but as long as this thesis does not aim to clarify these notions, further discussions on this topic are left aside and the most common models to assess environment for creativity are analyzed.

One last interesting observation is that the creative climate is also used as a measurement to analyze climate in scientific organizations (Gaddis et al. 2003), because creativity is one of the key climate concerns unique for scientists and academics. This proves the usage of this concept in this research as well. Therefore, models of creative climate are discussed next.

There are two most famous approaches to evaluate organizational creativity: by using a scale to evaluate creative climate developed by Ekvall (1996) or KEYS approach by Amabile (1996). There is one more model which has been found and which is constructed based on Amabile's theoretical factors, but specifically implemented for studies of physical environment. Each of these models distinguishes between factors that have a positive and negative effect on organizational creativity. The comparison table is presented in Table 2.

Table 2: Comparison of factors that have positive and negative effect on organizational creativity (based on Amabile (1996), Ekvall (1996), McCoy and Evans (2002))

Effect on organizational creativity / Author(s) of the model	Amabile (1996)	Ekvall (1996)	McCoy, Evans (2002)
Positive	Organizational encouragement Supervisory encouragement Work group support Sufficient resources Challenging work Freedom	Challenge Freedom Idea support Trust/Openness Dynamism/Liveliness Playfulness/Humor Debates Risk-taking Idea time	Nature Challenge Freedom Support Coherence
Negative	Organizational impediments Workload pressure	Conflicts	Threat Status quo

There are also other models to assess climate for creativity (Hunter, Bedell and Mumford 2007), but they are not considered in this thesis due to two reasons: they are more complex and usually divide the elements of the previous models into separate and more miniscule components, which does not provide a lot of help for this particular research (for example, Hunter, Bedell and Mumford (2007) differentiated 14 distinct factors), and, secondly, they are not as established in research as the aforementioned models.

The Creative Climate Questionnaire (CCQ) by Ekvall (1996) takes into account 10 factors: challenge, freedom, idea support, trust/openness, dynamism/liveliness, playfulness/humor, debates, conflicts, risk taking and idea time. Table 3 provides description of each factor. All the factors except one (conflicts) are thought to have a positive effect on creativity. This model was later transformed into SOQ model (Situational Outlook Questionnaire) with the same dimensions. This SOQ

model has multiple uses: to compare innovative and stagnated companies, most and least creative teams, levels of perceived support for innovation, et cetera (Isaksen and Akkermans 2011). Due to multiple usage of this model, the dimensions of CCQ and SOQ are well established in practice to evaluate not only creative climate, but also climate for innovation.

Table 3: Creative Climate Questionnaire (Ekvall 1996)

Factor	Description
Challenge	The degree to which the people of the organization are emotionally involved in its operations and goals and find pleasure and meaningfulness in their job
Freedom	The independence of behavior exerted by the members of the organization. In climates with a great deal of freedom people are given autonomy to define much of their own work
Idea support	The ways new ideas are treated. In the supportive climate managers and colleagues receive ideas and suggestions in an attentive and receptive way and there are possibilities for trying out new ideas
Trust/ openness	The degree of perceived emotional safety in relationships. When there is a strong level of trust, everyone dares to present ideas and opinions since initiatives can be taken without fear of reprisal or ridicule in case of failures
Dynamism/ liveliness	In a dynamic climate new things happen all the time and there are frequent changes in ways of thinking about and handling issues
Playfulness/ humor	The perceived ease and spontaneity, a relaxed atmosphere with laughter and jokes
Debates	Encounters, exchanges and clashes among ideas, viewpoints, and differing experiences and knowledge. Many voices are heard and people are keen on putting forward their ideas
Conflicts	The degree of emotional and personal tensions in the organization, In climates with high level of conflicts, groups and individuals dislike each other and there is considerable gossip and slander
Risk taking	The tolerance of uncertainty in the organization. In the high risk-taking climate, decisions and actions are rapid, arising opportunities are seized upon, and concrete experimentation is preferred to detailed investigation and analysis

Factor	Description
Idea time	The amount of time one can use for developing new ideas. Organizations characterized with much idea time are giving possibilities to discuss and test impulses and suggestions that are not planned or included in the task assignment

Some of the features of the creative climate are discussed in the manner of cultural norms for innovation in the works of other authors (Pervaiz 1998), such as challenge, freedom and risk taking, dynamism, trust and opennness, debates, innovation time with some other factors different from those of the creative climate model. This only emphasizes the vagueness of notions “climate” and “culture”, but it certifies the usage of Ekvall’s model in conjunction with the model of organizational culture of Schein (1990).

The second widely used approach is called KEYS (the Work Environment Questionnaire) by Amabile (1996). In this model, factors are divided in two groups: stimulants and obstacles with positive and negative effects on creativity consequently. These factors with their definitions are presented in Figure 2.

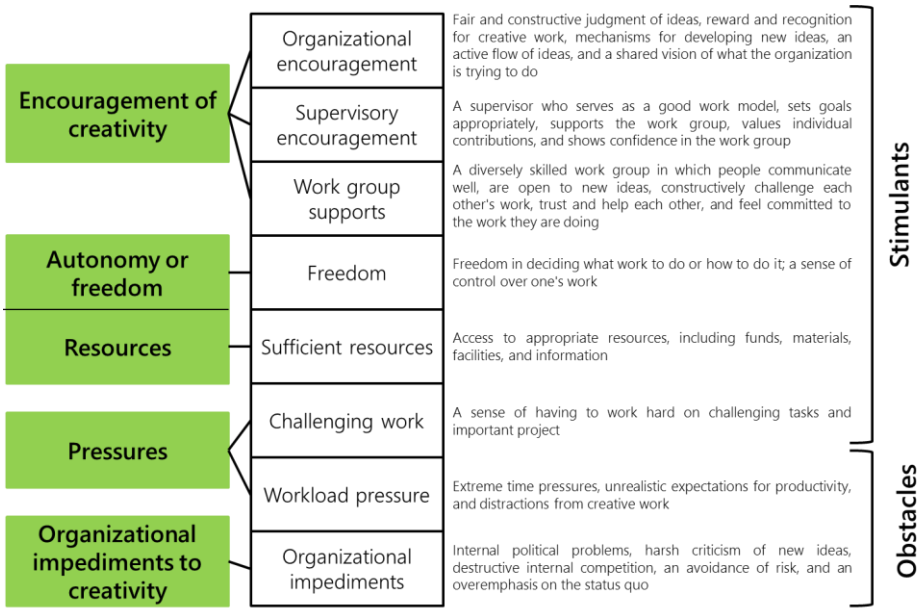

Figure 2: KEYS models (modified from Amabile (1996))

Although both models try to evaluate the same phenomenon, depth of analysis and elaboration of factors differentiate them. Because there is an agreement that all the factors are altogether important in Ekvall's model, this model represents organizational creativity in a more robust way. However, it could also be stated that the uniformity expressed through Ekvall's model makes the factors too broad and, thus, Amabile's model provides more detailed or valid representation of organizational creativity (Moultrie and Young 2009). Thus, these models may be chosen for a research depending on a particular case and circumstances.

Both models are often used to evaluate the creative climate in organizations: some authors give preferences to using Ekvall's model party "because of the range of factors covering creative climate within an organization, both stimulating and hampering innovation" (Ismail 2005, 642), while other authors prefer to use Amabile's model (Ensor, Pirrie and Band 2006). The Ekvall's model is also used to evaluate innovative climate (or, as stated in some other sources, innovation climate), for example, in the works of Turnipseed and Turnipseed (2013); Björkdahl and Börjesson (2011), which shows a broader range of applicability of Ekvall's model. Furthermore, even in the initial paper, Ekvall (1996) himself named its model as climate both for creativity and innovation.

However, because each of the models contains parameters that cannot be implemented towards evaluation of the physical environment, McCoy and Evans (2002) made a list of modified characteristics of the physical environment based on the Amabile's model. Such factors as nature, challenge, freedom, support, coherence, threat and status quo were included in the final model. The description of these characteristics and their connection to physical environment is shown in Table 4. Overall, this model serves as a proof that it is possible to interpret the elements of creative climate from the perspective of physical environment.

Table 4: Modified model of creative climate (McCoy and Evans 2002)

Factor	Description
Nature	Nature has the restorative qualities to creativity as a process that is enhanced by contact with natural elements
Challenge	An environment that is intricate or complex, offering a promise of more information if explored is high in challenge
Freedom	A free environment also allows diversion and, reflecting flexibility, offers a degree of personal autonomy
Support	Support implies agreement between psychological and physical conditions required for the task function
Coherence	Legible and familiar environments that offer spatial distinction and clear definition are coherent
Threat	The design of the physical environment can either enhance or inhibit efficiency of task performance. Just as hierarchical design may contribute to competition for status; it may also contribute to conditions of perceived evaluation
Status quo	A rigid environment in which conformity is apparent, that has boundaries not intended for change or manipulation

As for the established models, both of them (of Amabile and of Ekvall) have some common factors despite the different naming of those. For example, the presence of challenge and freedom is obviously expressed in two models. The issue of necessity of employees to feel support for their creative endeavors is incorporated into one factor of idea support in Ekvall's model, while Amabile identified several types of this support: organizational and supervisory encouragement, as well as work group support. In the same vein, idea time of Ekvall is interpreted as workload pressure in Amabile's work. Finally, it seems that Ekvall's model provide more dimensions (such as, dynamism/liveliness, playfulness/humor) than the model of Amabile and the factors stated in Ekvall's model seem to be more easily applicable to interpreting the symbolic nature of physical artifacts and environment. Therefore, Ekvall's model serves as a basis to analyze the symbolism of the physical environment in this thesis. As long as some factors convey an almost similar message about the organizational climate; and for the sake of analysis clarity and simplicity, these factors were grouped into three

categories. The results are presented in Table 5. The following model is used to assess the symbolic meaning of physical environment in this research.

Table 5: Aspects of creative climate to assess physical environment (based on Ekvall (1996))

Symbolic aspect of the creative climate	Items of Ekvall's Creative Climate Questionnaire
Support	Conflicts Debates Idea support Idea time Freedom Risk-taking Trust/openness
Dynamism	Dynamism/liveliness Playfulness/Humor
Engagement	Challenge

2.5 Physical work environment and creativity

Importance of physical work environment in its connection to creativity is mentioned in many models (Amabile 1996; Woodman and Griffin 1993). However, despite that "there is limited knowledge on how the physical space actually enhances creativity" (Kristensen 2004, 89). Moreover, due to this limited knowledge and relatively few studies on this topic, there is no established framework to interpret physical environment via the prism of creativity. According to Sailer (2011, 7), "there is no coherent research agenda; rather, individual scholars have analyzed different and singular aspects of the relationship between space and creativity". Therefore, in this sub-chapter different existing frameworks to study creativity and the physical context are explored and analyzed. Generally, there are three types of these frameworks: analysis of physical environment via its separate characteristics and features, analysis of physical space via the prism of interaction (or interaction models), analysis of physical environment through its symbolic aspect.

2.5.1 Physical characteristics of environment influencing creativity

There is a stream of research exploring how different features of physical work environment influence creativity. It is studied either by creating different space settings and administering creativity tests (McCoy and Evans 2002); or in the form of case studies by creating or modifying a place to stimulate creativity and collecting feedback (Martens 2011); or by analyzing some office restructuring and comparing before- and after-opinions (Parking et al. 2011). The main drawback of these researches is that different aspects of physical environment are included into studies and there have not been found a study that incorporates all the possible features found in different literature sources. Therefore, these studies cannot be called comprehensive and the models usually concentrates on only one aspect of this complex phenomenon, which results in the fact that there is no unified model to assess connection between physical environment and creativity.

Secondly, despite the existing diversity of approaches to view this issue, majority of authors pay more attention to office layout rather than analyzing the issue to the full extent. Thus, for the purposes of this research, it is necessary to combine different physical characteristics which are thought to influence creativity and then identify the level of their importance.

Starting the discussion about particular features of physical environment related to creativity, one model by McCoy (2005) can be analyzed as an initial point. In this model, characteristics of physical environment are divided into several groups: spatial organization, architectonic details, resources and ambient conditions. These features also analyzed from the point of view of how they affect social behavior pattern important for creativity. However, this model is different from interaction models, because it analyses physical characteristics not only from the perspective of communication and collaboration, but it also includes other social behavior aspects. Despite the fact that this model is highly detailed and represents physical environment from two angles: as a composite of features and as a factor affecting social side of creative work, some characteristics are not fully covered (such as ambient conditions and resources). The model is shown in Table 6.

Table 6: Characteristics of physical environment with effect on creativity (McCoy 2005)

Characteristics of Physical Environment	Influence on Social Behavior
Spatial Organization	
Proximity to team members; Proximity to resources	Interaction, communication; Supports team functioning
Efficiency of layout	Optimizes functionality
Dedicated, shared space	Interaction, communication, collaboration, encourages cohesiveness, cooperation
Informal spaces	Random encounters encourage communication, playful behavior
Visual access	Interaction
Traffic, visual exposure	Distraction
Multiple places to work; co-location	Diverse, unusual ways of working Autonomy
Size of space to fit size of team and task requirements	Privacy, control, isolation Optimizes functionality
Flexible, adaptable spaces	Minimizes disruption
Meeting spaces	Communication; Collaboration
Architectonic Details	
Displayed thinking	Focused communication Group identity expressed-
Cues	Desired behavior communicated
Cue-rich	Inspiration Unique Associations
Personalization	Group identity expressed Territory defined
Participation in the design Process	Commitment to the team Autonomy expressed Territory defined
Resources	
Accessible technology	Focused communications Access to domain
Ambient Conditions	
Noise	Distraction
Comfort	Motivation and endurance

Some other works include less detailed analysis of physical environment and they take into account only few characteristics. One of such models is that of Sheykhan and Saghaee (2011) where only the following physical features are identified (features are presented in the ranking of highest importance according to the study):

- A computer with necessary software packages,
- A working environment with sufficient light,

- Diversity of the number of working facilities,
- The quality of communication,
- A good phone communication,
- A comfortable sitting chair,
- A good air-conditioning facilities,
- The arrangement of furniture,
- The availability of a good library,
- The availability of natural flower,
- The availability of some painting and pictures hanging around.

Although Sheykhan and Saghaee (2011) identified and proved by regression analysis the importance of some of these criteria, they did not propose a particular model to analyze these physical attributes, they stated is just as a list – a drawback found in the works of other authors as well. For example, the work of Jaskyte et al. (2010), which aimed to analyze elements of work environment in nonprofit organizations that enhances creativity, distinguished a separate cluster for physical environment "Workplace settings and resources", but it only consisted of 4 components: available resources to promote ideas and inspire creativity, creative and efficient use of office space, a décor (colorful walls, rugs, artwork and other features which create a pleasant work environment) and good lightning. Although this limited number of physical characteristics is explainable, considering that this model has multiple factors (and mostly non-physical ones) in the final regression analysis; the usage of 4 elements of physical work environment seems to be not enough to understand the effect of such a complex issue, for analysis of which other authors use more detailed lists of physical characteristics.

The same approach of stating elements of the work environment and then analyzing them with statistical methods was encountered in the research of Dul and Ceylan (2011). Although their model has quite a profound list of physical attributes influencing creativity, the clear structuring of these elements is still missing. Their model is provided in Table 7. Researchers also state that although it is accepted fact that physical environment has an influence on creative

performance even in the flagship works on creativity (Woodman and Griffin 1993), “no specific details are provided as how the physical work environment could enhance creativity” (Dul and Ceylan 2011, 15). The same model was used afterwards in the research of Dul, Ceylan and Jaspers (2011). And even though the full range of ambient conditions (temperature, smell and other factors) included in the model may seem to be more related to the question of productivity or quality of a workplace, they are still important factors influencing organizational creativity. According to the words of McCoy (2005, 183), “if we know that ambient conditions influence work performance, it is logical to assume it can also influence the performance and achievement defined as creativity”.

Table 7: Physical factors of work environment influencing creativity (Dul and Ceylan 2011)

№	Element	Description
1.	Furniture	Furniture (e.g. chairs, tables, cupboards), that are places in the workplace
2.	Indoor plants/flowers	Natural plants or flowers that are places in the workplace
3.	Calming colors	Colors that provide a relaxing experience (e.g. green, blue or blue/violet)
4.	Inspiring colors	Colors that provide a stimulating experience (e.g. yellow, orange, pink, red or red/violet)
5.	Privacy	The possibility of being away from the presence of view of others
6.	Window view to nature	Having visual access from the work environment to the outer natural environment (e.g. trees, plants)
7.	Any window view	Having visual access from the work environment to any outer environment
8.	Quality of light	The amount of light in the work environment
9.	Daylight	The light coming from the sun into the work environment
10.	Indoor (physical) climate	The temperature, velocity, humidity and composition of the air in the work environment
11.	Sound (positive sound)	Positive sounds (e.g. music, silence, absence of noise)

12.	Smell (positive smell)	Positive odors (e.g. fresh air, absence of bad smell)

McCoy, Evans (2002) took for analysis the following factors, many of which are identical to the physical elements which were already discussed:

- Spatial form (size and shape of the interior space),
- Light (quality and quantity),
- Internal organization of objects (furniture that promote social interaction and aesthetic visual details),
- Characteristics of bounding surfaces (materials, texture and transparency, including living plants),
- Color (warm and cold),
- Texture (the amount and degree of it),
- Transparency (visual access either to the exterior environment or to an adjacent interior environment).

Later on, McCoy and Evans (2002) identified elements, which have highest or lowest potential to influence creativity performance and checked them in a follow-up study by creating two environments in correspondence with the found elements and evaluating participants' performance on creativity tests. Table 8 presents the results. Such factors as visually detailed environment and use of natural building materials are emphasized more in this model than in other sources.

Table 8: Characteristics of physical environment with high and low potential to influence creativity (McCoy and Evans 2002)

High Creativity Potential	**Low Creativity Potential**
Spatial complexity	Cool color temperature
Visually detailed	No view
View of natural environment	Manufactured/composite material
Use of natural materials	
Sociopetal design*	

*Radial space that supports interaction and communication due to merging or overlapping routes

The same factors that were stated in the previous models are reiterated in the study of the creative classroom (Warner and Myers 2010). In this research, which studied the influence of the physical environment on students' creativity, the found facts correspond with the abovementioned statements. Lighting, color, decorations, furniture, resources, sensory variables, space configurations were scrutinized. The best variant of lightning was found to be natural or, at least, full-spectrum tubes. Regarding colors, it is argued that loud colors are cultivators of loud ideas (Lloyd 2001). Some decorations, such as paintings, can prompt creativity. As for furniture, it should be not only functional, but also inviting to sit and to collaborate with other people at this place; if people do not feel comfortable using this furniture, the duration of interactions may decrease. It is stated that without resources, creativity may be diminished, because in order to create, you need to have something to experiment with; the same situation may be seen at work – if there is not enough sources to support creativity (for example, sheets of papers or rooms for brainstorm), creativity may suffer. Thus, Warner and Myers (2010) highlight the importance of non-technical resources, a component ignored by many other authors. The already mentioned sensory variables, such as temperature, sound (as well as music), availability of fresh air, are also indicated. If it is too hot or too cold, person's creative capacity may go down, as for fresh air, Lloyd (2001) says "Nothing happens without oxygen". Techniques that can be used to make existing space configurations amenable to a creative environment include the use of wall and ceiling colors that convey the sense of openness, as well as putting machines, benches, and cabinets on wheels so that they can be moved to reconfigure the room as circumstances require and needs change (Warner and Myers 2010).

The previous models mostly enumerate the physical characteristics of environment connected to creativity; in some cases, they also divide these elements into groups according to their origins similarity. Other authors (Oksanen and Stahle 2013) define the attributes of innovative space according to their functional role (turn to Table 9). There are two levels outlined in this model: desirable attributes of physical space and attributes that constitutes an innovative (as well as creative) space. Although this model is highly related to the previous

ones: in order to improve well-being of people, a space needs to have good ambient conditions and it should have multiple technologies installed so that to be considered a smart place. However, this model shows a bit different two-level view to connect physical environment with creativity and innovation.

Table 9: Functional model to assess physical environment for effect on creativity (based on Oksanen and Stahle (2013))

Attribute level	Function	Attributes
Desirable attributes of physical space	• Physical space improves the well-being and happiness of people • Physical space can be modified in order to meet the diverse needs of different people • Physical space encourages communication and enables collaboration • Physical space fosters creativity	Modifiability Smartness "Space as an innovative service" (intuitive platforms that offer resources that users can select, utilize, modify, and create)
Attributes-constituents of an innovative space	• Innovative space highlights team-work and the communicative aspects of working and studying (it supports collaboration) • Innovative space is creatively designed (it is attractive) and reflects the personality and values of users	Communicativeness Attractiveness Value reflection

The last model which was found is that of Kristensen (2004), where analysis of physical environment is done from the unique angle of mental processes which occur throughout the creative process. These mental processes are:

- value creation processes,
- scaffolding,
- imagination processes,
- materialization processes.

The last three stages are most important in their connection to physical attributes. For scaffolding, layout is one of the central components and the basic configurations are divided into these groups: centralized, linear, radical, clustered and grid. Each of these configurations has its own advantages and disadvantages in terms of creative process and space for individual and group activities. Some decoration and personalization is important for imagination processes, and this does not include exclusively images or models, but also some “odd artifacts”. “A clean desk with no personal belongings seems to create a sterile environment that inhibits imagination” (Kristensen 2004, 93); therefore, participation in design and personalization are given high priority. For the last type of processes - materialization, availability of tools for prototyping and models is significant. Thus, it implies that physical space shall be equipped with necessary non-technical resources and tools. What is more important is that these mental processes do not go in parallel with stages of the creative process developed by Wallas (1926) and it means that the aforementioned attributes shall be present throughout to support creativity.

There are also some works that study the relation between physical environment and creativity, but they do not provide a specific structured framework. They provide general discussions of effect of some particular physical features on creativity or on creative performance. One of such work is that of Martens (2011). Martens (2011) reiterates some of the factors which support creative interactions such as necessary vicinity and higher density of employees. On the other hand, some new factors are mentioned, for example, staircases are believed to impede communication between staff. New dimensions of studying creativity and workplace are introduced: factors supporting “flow” and personal qualities for creativity. The concept of “flow” as well as “ba” is explored in detail in the interaction models of physical work environment. However, there is a specific requirement for a place which supports concentration and attention and also keeps mental fatigue levels under control. Such elements of physical environment as noise and windows are emphasized. Martens (2011) state that sound proofing for noise reduction will eliminate sources of interference, while a view to natural

elements plays a restorative role and reduces fatigue; altogether, this helps to sustain “flow”.

British Council for Offices proposes the rule of “three Es” to analyze how physical environment influences performance management: measures of efficiency (cutting occupancy costs and other business costs), measures of effectiveness (value added by design to business performance), measures of expression (success in broadcasting business values externally and internally) (British Council for Offices 2005). In the context of our study, components of effectiveness of the physical workplace are of particular interest. The notion of effectiveness described in this source is highly similar to some physical attributes discussed in connection to creativity. Three components of effectiveness and their comparison to other models can be found in Table 10. The similarity of the concepts shows that physical characteristics important for creativity and for productivity and performance are not fully distinguished.

Table 10: Comparison of effectiveness of physical environment with concepts in other models (based on British Council for Offices 2005; Oksanen and Stahle 2013; Dul, Ceylan and Jaspers 2011; McCoy 2005)

Components of effectiveness	Similar concepts in other sources
1. Adaptability and flexibility: achieving appropriate level of extendibility and flexibility of infrastructure (building systems, structure and services) to be able to respond to change quickly.	Modifiability (Oksanen and Stahle 2013)
2. Staff performance: • health and comfort providing for the health and comfort of occupants; • alignment with process - effective alignment of workplace with work practice and process; • internal expression – communication of messages to staff about corporate values and how business values their workforce.	Ambient conditions (Dul, Ceylan and Jaspers 2011) Comfort (McCoy 2005) Value reflection (Oksanen and Stahle 2013)
3. External expression: management and communication of external messages such as	Value reflection (Oksanen and Stahle

company brand and corporate values.	2013)

The work of Pitt and Bennett (2008) shows once again that there is no clear line between defining a place beneficial for performance and for creativity. Pitt and Bennett (2008) made a case-study on one of the most successful companies in UK, Drivers Jonas LLP and found some techniques used by the company to promote motivation in its walls. Workplace settings and rules (hot-desking, touchdown areas, bookable offices, break out places, group collaborative workplaces), open space planning (for example, use of glazed doors), color scheme, perimeter fenestration (access to windows and artificial lightening), areas for gaming and recreational activity was found to affect employee' satisfaction with the workplace and their performance. All these factors are similar to those mentioned in the models which connect physical environment and creativity.

Workplace decorations are also discussed in their connection to creativity. A physical work environment that is perceived as attractive can be inspirational and motivational to people and can symbolize innovation and signal creativity (Haner 2005). Other authors (Jaskyte at el. 2010) also mention that such factors as presence of creative décor (colorful walls, artworks, rugs and so on) are conducive to organizational creativity.

Harvard Business School proposes its own creativity checklist to evaluate physical workspace which mostly emphasizes the importance of space diversity (casual meeting space, space for quiet reflection, employee-only space, customer contact space, space for individual expression and game/relaxation area), but it also mentions physical stimuli (book, art on walls, et cetera) and variety of communication tools (whiteboards, bulletin boards, et cetera). The technological side of the physical environment is highlighted by other authors, for example, Magadley and Birdi (2009) posit that technologies (in their research about innovation labs) are as much important as the physical environment itself and the message it communicates.

Some other sources, such as consulting reports, also analyze the physical elements of a work place and give guidelines about what elements distinguish good or bad work settings. The report "What makes a great workplace" (Kahler Slater experience design 2010) take a look at a workspace as most productive for knowledge workers, a place that is supportive for creation of knowledge and, thus, partially of creativity. In this case, the connection with creativity is also not stated directly, the identified factors are similar to those already mentioned: combination of individual and communal spaces, such perceptional characteristics as thermal control, daylight and control of computer glare, ergonomics of the workplace, accommodation with the technologies, "a professionally-maintained plant program" and expression of organizational culture. Some features in the report are relatively new: accommodation of personal work styles and workstation personalization, and clear wayfinding (which is again mostly related to easier collaboration and communication).

The report "Innovative workplaces: benefits and best practices" (GSA Office of Governmentwide Policy 2006) provides a framework for innovative workplaces (places which allows for work productivity and stimulate high-performance work environment). The characteristics of such innovative workplaces are presented in Table 11.

Table 11: Characteristics of innovative workplace (GSA Office of Governmentwide Policy 2006)

Characteristics of innovative workplace	Description
Spatial equity	A humane, well-designed workspace that meets the user's functional needs and provides individual access to privacy, daylight, outside views, and aesthetics
Healthfulness	Clean and healthy work environments with access to air, light, and water— and free of contaminants and excessive noise
Flexibility	Easily reconfigured infrastructure and furniture, including freestanding work surfaces, mobile storage units, modular walls, and access floor systems

Characteristics of innovative workplace	Description
Comfort	Occupant-adjustable temperature, ventilation, lighting, acoustic, and furniture systems providing personal and group comfort
Connectivity	A robust communications system providing access to people and/or data from any place, at any time
Reliability	Efficient and state-of-the-art building, security, computer, and telecommunication systems that are easy to maintain
Sense of place	A workplace that has a unique character, with an appropriate image and identity, instills a sense of pride, purpose, and dedication for the individual and the workplace community

Although these reports (Kahler Slater experience design 2010; GSA Office of Governmentwide Policy 2006) seem to state the features that are mostly related to wok productivity, almost all of these features are similar to those mentioned in academic articles on physical environment and creativity. However, "2013 U.S. Workplace Survey" report (Gensler 2013) specifically distinguish some attributes of a work place that drive innovation: drivers of focus (satisfactory noise level, functionality, design look and feel), drivers of balance (meeting space, circulation and support space, in-office amenities) and drivers of choice (variety of spaces, tools and policy).

A separate branch of research studies creativity and innovation spaces (they can be called differently, but one of the most used terms is innovation lab). These spaces are dedicated facilities which are supposed to be used of necessity and separately from the day-to-day work. The idea behind these spaces is that there are many distractors at work that impede creativity and "working in innovation labs may clear employees' minds and allow them to focus solely on the creative task, free from disruptive interruptions" (Magadley and Birdi 2009, 316).

These innovation labs or similar facilities are usually realized as special projects to create spaces for creativity (Martin 2010). The approaches to create such places reflect the same ideas as the theory suggests. For example, Creative Center at

University of Brighton was created so that it was a creative learning environment. Some highlighted characteristics of this place are reconfigurable space, write-on and moveable walls, a diverse range of furniture to support different activities, bean bags with bright color to enliven the space and to create a bit informal atmosphere, plants, games, carpeted flooring that softens the sound and minimizes echo and also serves a place to sit on and relax, colored lightning which creates a different atmosphere depending on the color in use. Temperature control system and olfactory system are also integral components of the project as well as advanced technologies. As it may be noticed these practical projects follow the same pattern to create a creative space by making it comfortable, functional and unique in terms of experience (by introducing colored lightening and bean bags). The usage of color to design spaces for different purposes is not unique. For example, the concept of de Bono thinking hats and its colors were used for creation of the Learning Garden by one Scandinavian financial institution. The process arena (a meeting place) was colored yellow; the exploration space white; the creative garden got a color of red for the reasons of flexibility and stimulation; the consensus court (a place for making decision) is colored in grey to be more neutral and formal; and the production studio is blue where refinement and further work takes place (Haner 2005).

In the end, several conclusions can be drawn from the analyzed models and theories. Currently, there is no established and thorough list of all physical attributes potentially important for creativity and their functional classification. Different authors hypothesize about importance of different physical features, which makes it difficult to completely compare the existing models. Secondly, authors structure physical features in different ways and there is no established way of features' categorization, which does not allow studying the effect of physical environment in categories. Last, there is no clear way to distinguish physical features important for creativity and productivity and they are usually mixed in the studies.

2.5.2 Physical environment: interaction models

Despite the title, interaction models do not consider only communication and collaboration issues, but rather they study the topic from both sides. And the second topic which usually accompanies discussions about interaction is privacy. The main principle behind these interaction models is the theory of creative process.

Haner (2005) proposes the following model to study efficiency of physical environment in terms of its support for creativity. The model (shown in Figure 3) implies that both team and individual efforts are important for creativity and both types of thinking – divergence and convergence – are also necessary throughout the creative process.

	Divergence	**Convergence**
Team	Brainstorming	Deciding
Individual	Browsing	Analyzing

Figure 3: Model to analyze physical environment based on dimensions: team-individual work and divergent-convergent thinking (Haner 2005)

And, as a result of this model, Haner (2005) posits that the following criteria (levels) are suitable to analyze organizational spaces in terms of stimulating creativity and innovation:

- A geographical level,
- A level relating to the buildings and their layouts,
- A style level which refers to design and décor.

The first level refers to the need of face-to-face communication during creative endeavors (especially, when this is a group project) and, therefore, the centralized location may help in the creative process. Despite the fact that there are multiple technologies nowadays to manage virtual teams, the real communication is thought to be crucial in any case. The second level means provision of support for formal and informal communication so that to enhance mutual support and knowledge sharing. Some elements of effective layout are described as well:

proximity, visibility and density. Further on, these attributes may be interpreted on multiple levels as well: for example, proximity means not only physical co-location of employees, but also physical barriers for communication (for example, staircases). Visibility, in turn, may be enhanced by using transparent building materials (for example, glass). And even though the layout question always goes back to the discussion of particular physical characteristics, the underlying idea behind it differs from other models. The last element was already mentioned in the previous sub-chapter. According to Haner (2005), style and attractiveness shall not be mistaken for decoration; rather an attractive place shall serve as an inspirational symbol of creativity and innovation.

Some particular features of layout that can be beneficial for interaction are highlighted by Oseland et al. (2011): proximity, accessibility (including the known availability of meeting spaces), privacy, legitimacy (meaning that a person has a valid reason to be in spaces where interactions may occur) and functionality. The interesting point here is that even for interaction people need to have some privacy, which, on the first sight, seems to be more connected to performance of individual work. The importance of privacy is one of the central topics in the research of Parkin et al. (2011), where the authors studied the reconstruction of two academic offices in their relation to collaboration and privacy issues. An interesting finding was found regarding suitability of one of the environments with a lot of open office spaces for different activities: occupants did not find it apt neither for collaborating with colleagues nor for concentrated or creative work; and informal interaction with colleagues was identified as the most suitable activity. This puts under doubt the fact that open office may stimulate collaboration at work. Comparing the satisfaction from the change of offices to meet the demands of both collaboration and privacy, the satisfaction with the second environment (which was primarily constructed for individual work) changes higher than for the first open office environment. That can be a sign that spaces for individual work are still valued higher by academics than places for group work and discussions.

However, that is still an unclear issue. Martens (2011) interviewed employees about the fact how having people around can support their creativity by exposing them to different ideas. The case company opted for open plan offices with standardized work places which allow for faster and easier change of teams and their working places. The attitude towards balance of communication and concentration among employees differed: ones felt more comfortable sketching something when there is a buzz around (for some employees, the buzz is even a factor of a creative environment), when others preferred to find some distant places of intimacy.

This example is in the line with the theory on the cognitive performance of employees: the effect of the distracting environment of open-plan offices depends on the level of distractibility of a person. People with high level of Distractibility Index (DI) may show worse cognitive performance, while people with low level of DI may even benefit from this environment (Purdey and Leifer 2012). One more practical example concerning privacy is found in the study “Coding War Games”. It was shown that the more privacy developers have, the better they perform. Comparing the performance of participants on particular tasks, it was found that those who performed better had more workspace and these workspaces were more private. This supports the fact that performance of such type of workers depends on the amount of privacy, personal workspace and freedom from interruptions they have (DeMarco and Lister 1999).

In this sense, interaction can be studied via the prism of knowledge creation and “ba” concept. “Ba” refers to a shared space for emerging relationship and it can be a physical, virtual or mental space (Nonaka, von Krogh and Voelpel 2006). However, the presence of actual physical space is important for different types of “ba” – for originating “ba”, where face-to-face meetings are important, to interacting “ba”, where the getting feedback from peers is of high value. And as long as interaction is important exactly from this point of view of sharing knowledge, there are some works (Appel-Meulenbroek 2010) that specifically study the relationship between physical environment and knowledge sharing. Appel-Meulenbroek (2010) states that co-presence is highly important for

knowledge sharing with the following characteristics attributed to co-presence: visual/aural accessibility, proximity and meeting areas. However, knowledge sharing is not the only reason, for which such an important factor for creativity as collaboration and communication is needed.

The similar effect of layout is also highlighted by D. Lamproulis (2007), who brings forward the psychological issues of workplace design on employees' creativity. Physical space and layout can work as enhancers of communications and open interactions between employees, and thus, facilitate the idea cross-fertilization. However, physical space and layout can also make people feel relaxed, create a feeling of equity among staff and a sense of ownership, which altogether result in broader creativity capabilities of personnel.

The aforementioned issue of geography is the main concept under investigation in the research of Tornqvist (2004), where so-called milieux of creativity are studied – "geographical areas and places that are perceived as forges of creativity and renewal" (Tornqvist 2004, 229). In the modern world, Silicon Valley can be associated with this term. And although the idea behind this theory is not directly connected to physical work environment but rather to creative clusters, it provides an interesting idea that organizations may also benefit from being exposed to external ideas coming from the outside of the organization and from networking.

Sailer (2011) suggests "to investigate the spatiality of creativity not directly, but indirectly" (Sailer 2011, 8) via using two criteria to evaluate how physical environment supports creative work processes:

- interaction pattern (based on the idea of cross-fertilization),
- spatial configuration (based on different stages of creative process and, thus, a need for a balance between communal and private spaces).

There are four stages in the creative process, which are preparation, incubation, insight and evaluation/elaboration. On each of these steps, a creative person has different needs, which should be accommodated differently. Whereas preparation and elaboration needed both communal and private spaces, the stages of

incubation and insight were seen as more embedded in private spaces (Kristensen 2004). In the work (Sailer 2011), the refurbishment of one company was studied and complemented with staff surveys about the effects of the changes. The main finding was that a company moving to a new place and employees working under one roof due to the new design resulted in better collaboration and communication between personnel.

The similar idea about the need to have both communal and private spaces is expressed in the study of Bisadi, Mozaffar and Hosseini (2012), where the authors analyzed influence of such spatial characteristics as privacy, beauty, spatial diversity and proximity on two most important (according to authors) factors for creativity and innovation as creative thinking and communication. To study this phenomenon, the spaces were divided into two types: offices and common areas. Some interesting results were found: beauty impact more creative thinking in both cases; spatial diversity impacts more communication in common areas and creative thinking in offices; there is a greater effect of proximity on communication rather than creative thinking in both settings; and privacy has a bit higher influence on creative thinking rather than communication both in offices and common areas. These findings show that different features of physical environment can affect all the activities necessary for creativity – both creative thinking and communication.

The next research with the same underlying idea, but a larger number of factors taken into consideration is that of Martens (2011). The research provides a framework to analyze how physical environment can support creativity and divides support into the following categories:

- Support of creative process,
- Support of creative interactions,
- Support of flow ("Flow is the experience of timelessness and oneness with the activity in which one is engaged" (Martens 2011, 69)),
- Support of creative thinking and insight,
- Support of personal qualities for creativity – motivation and expertise,

- Support of a creative environment (reflection of identity and culture).

Although this framework is quite detailed and thorough, it has some overlapping attributes. For example, both creative interactions and creative thinking belong to the notion of creative process, but they are presented separately in this model. Therefore, this model does not provide a clear and unambiguous method to check physical environment for its support of creativity.

In practice, many organizations are prone to facilitate collaborative environments by creating many places for interactions at work. Teamwork is supposed to produce greater results than a single individual, but Cain (2012) argues that groupthink is not a sure-fire way for organizational creativity and refers to Picasso's words that without solitude, no serious work is possible. Cain (2012) gives an example of Steve Wozniak, who worked hard and alone on his invention – the personal computer. However, it is not a proposition to abolish altogether groupthink approach, but to reach the balance between thinking in groups and alone and to have places both for collaboration and for private reflections. The similar observations are found in the theory of "ba" by Nenonen (2004). According to this theory, analysis of physical workspace and its effect on knowledge creation can be done with using the notion of 'ba" – the space for creation of new knowledge. Open spaces with low boundaries and many meeting places facilitate transfer from individual tacit knowledge to group tacit knowledge, while a close and stable place with high and isolating boundaries facilitates transition from individual explicit to group explicit knowledge (Nenonen 2004).

Overall, despite the fact that the issues of interaction and privacy are highly connected to creativity and explain the necessity to have both communal and private places at work to support the whole creative process, this model alone is not sufficient for analysis of physical environment, which can contribute to creativity in other ways as well (for example, by influencing productivity or by transmitting the values of creativity and innovation to employees). So this model

should be accompanied with other theories to cover all the ways in which physical environment affects creativity.

2.5.3 Symbolic and value reflection aspect of physical environment

It is acknowledged that physical environment can express organizational culture and, thus, serve to reflect organizational values, including those about creativity and innovation. Many authors (Haner 2005; Pitt and Bennett 2008; Oksanen and Stahle 2013) mention this value reflection aspect as a part of their models connecting physical environment and creativity, but there are actually almost no models to study this feature of physical environment separately.

First of all, value reflection was already explored with the model of Oksanen and Stahle (2013). The authors provide only a small explanation of this fact by giving an example of IDEO firm and without further details on how it can be investigated more deeply:

"The IDEO space consists of team project rooms, an open studio for the designers and programmers, a prototyping workshop, a cafe, a community garden, and so forth. The variety of spaces supports the firm's values and working life and inspires people" (Oksanen and Stahle 2013, 823).

The model of Martens (2011) also includes a component of value reflection (in the terms of the model - "support of a creative environment"). Martens (2011) state that a "nice' environment can facilitate a creative culture and help to attract creative people. This description of the nice environment may be a reference to some physical attributes such as plants, colorful settings, art works and so on. However, the examples of "garage" creativity and "skunk works" phenomenon are also widely known.

In practice, the fact that the physical environment can fortify the image of an open and innovative organization through its workplace design has been exploited for a long time. A special and unique design can be a building asset of creative organizational culture like in the case with Google. And going back to the

question of design abundance or scarcity of resources, “the lack of resources can also be a driver for creativity. Microsoft, Google, all started in cheap spaces as basements, attics and garages. Start-up companies are often short of resources and have to deal with that through motivation, determination and creativity” (Martens 2011, 71).

Moultrie at el. (2007) introduces in the research so-called “physical embodiment of intent” – reflection of organizational goals about creativity and innovation in the physical workplace. The author claims that a company needs to have a thorough strategy to promote creativity and innovation in its walls and physical environment is a part of this strategy and, thus, it shall be aligned with the goals. They state that the design can physically reinforce three of Ekvall’s creative climate dimensions - dynamism, playfulness and debate. However, they go on saying that “despite much anecdotal evidence that the physical environment may positively influence creativity, there has been little empirical exploration of this phenomenon” (Moultrie at el. 2007, 59). To enable creative activities, physical environment shall not only reflect organization climate which supports creativity, but it shall also reinforce the desirable creative behaviors. Thus, not only the actual physical arrangements, but the perception of physical environment is also important.

Consulting reports also support the view that physical environment shall reflect the values of an organization (Kahler Slater experience design 2010) and give some examples when organizational culture is physically expressed in the design: for instance, the family culture may be reinforced by providing a large dining area, but it was not found in these reports which particular features of physical space may express a culture of creativity and innovation.

Pitt and Bennett (2008) maintain that the culture of creativity, openness and sharing that the company espouses is directly reflected in the design of the office environment and its space planning. They also provide some particular examples how certain elements may reflect this or that aspect of organizational culture: no assigned places or employees may symbolize a flattened hierarchy structure and,

thus, acceptance of new ideas; transparency and openness may be reflected in glazed doors. However, there is no discussion about how to study this phenomenon in detail.

Only two works were found that tried to study some form of symbolism of physical environment. Some attempts were made to find the connection between socio-psychological work environment (assessed by the model of Ekvall) and physical work environment (Vithayathawornwong, Danko and Tolbert 2003; Dul, Ceylan and Jaspers 2011) via calculation of correlation between them. In one of these researches, the hypothesis that the effect of the perceived support from the social-organizational work environment on creative performance depends on the perceived support from the physical work environment (Dul, Ceylan and Jaspers 2011) was rejected; while Vithayathawornwong, Danko and Tolbert (2003) found that the social-psychological work environment a mediator for the operational role of the physical environment in promoting creativity in organizations. In the model of Vithayathawornwong, Danko and Tolbert (2003), two most significant conditions of social-psychological work environment supported by the physical environment are dynamism and freedom. Overall, the results are inconclusive and show a necessity for further research on that topic. Moreover, it is still not clear which particular elements of the physical work environment support conditions of the creative climate (socio-psychological work environment).

There is also no determinate framework how to study physical environment via its connection to creative climate, because different authors propose their own models. Vithayathawornwong, Danko and Tolbert (2003) used the following dimensions in their research – dynamism, freedom/autonomy and trust, while Lewis and Moultrie (2005) insist on other dimensions: dynamism, playfulness and debate. Thus, this fact necessitates further analysis on connection of physical environment and creative climate.

In our research, in order to classify different elements of physical work environment that are thought to affect creativity, the model proposed by

Davis (1984) was used. This model states that the elements of physical work environment can be divided into three groups: physical structure, physical stimuli and symbolic artifacts. Physical structure is defined as "the architectural design and physical placement of furnishings in a building that influence or regulate social interaction" (Davis 1984, 272). Physical stimuli are those aspects of the physical environment that intrude into awareness of organization members and influence their behavior. And symbolic artifacts are the elements that guide the interpretation of the social setting individually or collectively. Moreover, there is no clear distinction whether this or that artifact belongs to a particular category. Davis (1984) gives the following examples: a building's size may be considered both as symbolic artifacts and as a structural variable; or furniture can be considered as a part of the physical structure and a symbolic artifact conveying the information about the image of the office. Overall, "physical phenomena can be examined from … multiple perspectives" (Davis 1984, 281). According to Hartel, Ashkanasy and Zerbe (2005), all three of these groups can affect people's perception of their environment and in their study they proposed that both physical stimuli and symbolic artifacts may facilitate the production of humor. Therefore, the elements of the physical setting were divided into groups as logically as possible in this research and all the groups are hypothesized to possess symbolic meaning and message about the creative climate in an organization. The support for the symbolic aspect of physical environment is also expressed by McCoy (2005, 184) who says that "the physical environment most likely cannot determine or predict creativity from a team. It may, however, support and enhance the team's capacity to be creative". Taking into account the duality of the physical space: objective and subjective aspects of it (Kristensen 2004), it seems fruitful to explore the effect of the physical environment on creativity via its symbolism (the implicit message that is conveyed to employees).

In the end, due to the high diversity of views on physical environment and its relation to creativity, the summary table (Table 12) with all the features found during the literature analysis was built for further usage in this research. All the attributes are divided into three groups suggested by Davis (1984) for the sake of

easiness of analysis. Because, initially, too many factors were identified from different sources, some of the factors were united into one category. For example, such factors as daylight, artificial light and quality of light were grouped into the category “Light” or, such factors as proximity, segregation, co-location, and the like were identified as a single factor “Proximity”, which reflects the idea of all the other variations of this factor.

Table 12: Summary table of characteristics of physical environment influencing creativity

Feature group	Features
Physical structure	(1) Accessibility (including stair-cases and way-finding) (2) Diversity (including smart, circulation and break-out places) (3) In-house services (sport facilities, food service, etc.) (4) Furniture (5) Gaming and recreational places (6) Layout and balance of private and communal places (7) Legitimacy/legibility (8) Light (including daylight, artificial lightning and glare control) (9) Proximity and segregation/co-location (10) Size
Physical stimuli	(11) Acoustics (12) Color (13) Density/movement/traffic (14) Sensory features (temperature, air quality, humidity) (15) Surveillance (16) Technologies (17) Visibility (including presence of glass)
Symbolic artifacts	(18) Attractiveness (19) Building materials (20) Décor (artwork, texture, visual cues) (21) Design of the workplace (22) Equality (23) Flexibility/modifiability/adaptability (as a type of furniture) (24) Personalization/participation in design (25) Plants and nature

Feature group	Features
	(26) Resources and tools (including suggestion boxes) (27) Windows and view (28) Work surfaces

3 RESEARCH METHODOLOGY

This chapter is devoted to a brief discussion of general research methodology and its typology and, after that, the explanation for the methods used in this research follows. Then the particular methods used in this research are explained in detail. Data collection of both primary and secondary data is discussed and delimitations of the chosen form of research are identified.

3.1 Research methods and tools

There are two generally-accepted types of research: qualitative and quantitative (Krishnaswami and Satyaprasad 2010). Each of them has its own benefits and they are applicable in particular situations and with particular research goals in mind. There are several fundamental differences of these two types of research (Bryman and Bell 2011). The most important differences are as follows: quantitative research deals with numbers, while qualitative one is more oriented towards analysis of words; quantitative research usually tests theory, while qualitative research serves to build an emerging theory; quantitative research (due to larger sample) has more hard and reliable data, while qualitative research provides more rich and deep content. Talking about the level of analysis, quantitative research is mostly macro-oriented, while qualitative research uses a micro-approach. Quantitate research is good for generalization of results; meanwhile, qualitative research requires contextual understanding. When performing quantitative research, the researcher is at a distance from his or her objects under investigation and, as a result, the study reflects mostly point of view of researcher (information is checked against the hypotheses). During a qualitative research, the researcher is much closer to the object and points of view of participants highly influence the roadmap of a study (information is extracted and then analyzed).

Considering the specifics of each research, a choice of this thesis' method shall be explained. As long as it was aimed to understand the connection between physical work environment and scientific creativity and to build a model for its further

analysis (there have not been found a framework for its analysis in the literature), the main task of this research was theory building, for which qualitative method is usually used. To build a theory, a deep understanding of the topic was needed, which could be acquired via interview method (a tool of qualitative research). Finally, the scope of this research was limited to scientific context with a sample consisting of researchers from Graduate School of Management, a faculty of Saint-Petersburg State University. Therefore, this research was micro-oriented. The aforementioned features of this research lead to a choice of qualitative methods to be used with some elements of quantitative methods to complement the findings with some descriptive data.

Considering qualitative method, the main strength is its ability to study phenomena which are simply unavailable elsewhere (Silverman 2006). While quantitative research is mostly concerned with establishing correlations between different variables, it gives us purely an "operational" definition of the phenomenon with its inputs and outputs (Silverman 2006), qualitative research allows seeing how this phenomenon is locally constituted, so the depth is one of the most differentiating features of qualitative research. And as long as this research requires a deep understanding of researchers' perception of physical work environment and their behavioral patterns, qualitative methods was rendered most appropriate for the purposes of this study.

The particular method tools used in this research can be divided into the following categories:

- Primary data analysis:
    - Interviews,
    - Qualitative questionnaire;
- Secondary data analysis.

Each of these tools is described in detail in the following parts of this chapter.

One more important feature of this research is that it is an inductive one. According to Bryman and Bell (2011), an inductive stance views theory as the outcome of research and the process of induction involves drawing generalizable inferences out of observations. As long as the aim was to produce a theoretical framework to analyze physical work environment in terms of its influence on scientific creativity, this research is also identified as inductive. On the other hand, induction is an alternative to link theory and research, it also contains a deductive element too (Bryman and Bell 2011). In other words, despite the fact that this thesis aims to build a new theoretical framework, the final model is based on the existing literature and theory modified according to the empirical findings.

To better understand how research is performed, the research techniques for every type of data are presented further.

3.2 Types of data

3.2.1 Primary data: collection and analysis

Primary data is data collected from primary sources, which, in turn, may be identified as "original sources from which the researcher directly collects data that have not been previously collected" (Krishnaswami and Satyaprasad 2010). There are several methods of collecting primary data: observation, interviewing, mail survey, experimentation, simulation, projective technique (Krishnaswami and Satyaprasad 2010) and every method has its own advantages and disadvantages, which a researcher needs to be beware of so that to insure the reliability of results and outline the delimitations of analysis.

In our research, the interview method and qualitative questionnaire are chosen as means of data collection. According to Krishnaswami and Satyaprasad (2010, 105), "interview is often superior to other data-gathering methods, because people are usually more willing to talk than to write". The main advantages of this methods is that it allows greater depth and detail of information (which is especially important for a research on a relatively new topic); a researcher has control over quality of information and can gather supplementary information (for

example, from observation) to enrich data; observation and probing during interview allows to check the accuracy of answers (which is not possible during sampling, when a researcher is at a distance from respondents); and, lastly, interview is flexible and adaptable to an individual situation. The main disadvantages of interview are that it is costly in terms of time and, sometimes, money; the respondent's answers may be influenced by the mode of asking questions and if not recorded, notes can be of faulty perception. Interview can be of several types: structured, unstructured and semi-structured. The last type of interview is used in this research, meaning that prior to every interview, a set of themes was generated, but the exact questions varied throughout different interviews. In terms of number of respondents at a time, interview can be individual or group interview. As long as group interview requires a professional interviewer which is experienced at moderating discussions and considering other disadvantages, such as a possibility of some respondents influence the answers of others, the individual interview was chosen to gain the most diverse and rich data.

As long as scientific creativity was studied in this research, the sample consists of researchers (including PhD students) of Graduate School of Management, Saint-Petersburg State University. The data collection procedure consisted of two subsequent steps. First of all, respondents were asked to fill out the questionnaire, which was aimed to not only acquire some numerical data to support our findings, but also to guide the line of thought of respondents in the right direction prior to interviews (due to complexity of the topic). Some respondents also noticed that the questionnaire helped them to gather their thoughts and to think and express themselves more clearly about the issue. Second step was an interview, which lasted from 15 to 45 minutes depending on a respondent and depth of experience with the topic. All the interviews were tape-recorded and transcribed. Transcripts were coded twice and the final codes were used for further analysis.

One expert interview was also conducted with the Head of Research Support Department at Graduate School of Management on May 20, 2014. The interview lasted one hour and it was also tape-recorded for the sake of subsequent analysis. Generally, the themes for this interview were similar to those of the interviews

with researchers; therefore, a separate list of themes of this interview is not provided in Appendices.

As for the qualitative questionnaire, it was tested on the first three respondents, the necessary changes were made and the questionnaire was not a subject to any modifications after that. For the questions, where respondents were asked to choose a numerical equivalent of their answer, a scale from 1 (Strongly Disagree) to 5 (Strongly Agree) was used for the following reasons:

1) The research is not a quantitative one, so there was no need in detailed answers to questions, but rather it was aimed to understand perceptions (either they are negative, neutral or positive).
2) A number of factors to assess in the questionnaire were counted at 28; thus, in order to simplify the scale measuring, 5-point scale was used so that respondents could fill out the questionnaire with a relative ease.

Considering the structure of the questionnaire, it was created according to the theoretical findings and factors that were found during the analysis of articles on the topic of physical work environment and its connection with creativity. Overall, the questionnaire was developed by the author herself, but it was based on the types of surveys and questionnaires that were found during literature review, though none of the survey was repeated completely. Structure of the questionnaire is as follows: questions 1 and 2 are used to understand what features are peculiar about scientific creativity and what part of scientific work is perceived to be creative, questions 3 – 5 serve to analyze physical environment and to find the most prominent physical characteristics related to scientific creativity, questions 6 – 11 are used to check whether the model of creative climate can be applied to analysis of physical work environment, and the last part (questions 12 – 17) are identification questions to see the demographics of the questionnaire.

Considering the demographics of the questionnaire and interviews, a summary table with respondents' information is presented in Table 13.

Table 13: General information about interviewees

№ of respondent	Research status	Gender	Language of interview	Date of interview
Respondent 1	Associate professor	Female	Russian	14/02/2014
Respondent 2	PhD student	Male	Russian	18/02/2014
Respondent 3	PhD student	Female	Russian	20/02/2014
Respondent 4	PhD student	Female	Russian	24/02/2014
Respondent 5	Associate professor	Male	Russian	25/02/2014
Respondent 6	PhD student	Female	Russian	27/02/2014
Respondent 7	PhD student	Male	Russian	01/03/2014
Respondent 8	PhD student	Female	Russian	03/03/2014
Respondent 9	Senior lecturer	Female	Russian	06/03/2014
Respondent 10	Professor	Male	Russian	11/03/2014
Respondent 11	Senior lecturer	Female	English	17/03/2014
Respondent 12	Senior lecturer	Female	Russian	18/03/2014
Respondent 13	Professor	Female	Russian	03/04/2014

Diversity of respondents (in terms of research status, gender and age) was maintained in this research to acquire as many diverse views as possible. In the end, there was a balanced sample of respondents that serves as an additional aspect of reliability of the findings.

As for data analysis, Bryman and Bell (2011) differentiate two types of qualitative data analysis: analytic induction and grounded theory. Analytic induction implies a process, where the initial hypothesis is checked during the data collection and the necessary modifications (redefinition or reformulation) to hypothesis are made in case when the data shows a different pattern. Grounded theory is the most widely used framework for analyzing qualitative data. This method employs several concepts such as coding, theoretical saturation and constant comparison. Both types of data analysis were performed during this research. Analytic induction was mostly used in relation to the symbolic model of physical environment, for which support was not found. And the new model, different

from the hypothesized one, was developed based on the principles of grounded theory.

Coding is used to signify the recurring patterns and themes in the qualitative written materials (for example, transcripts) and operate with the following items: codes, categories, themes; each of these items signifies a higher level of analysis, where codes are used to generate categories and categories are later summarized into themes. There are three stages in coding: open coding, axial coding and selective coding (Gibbs 2008). In this research, the coding process followed this established pattern: first, individual codes (in a form of a word or a phrase) in the transcripts were identified (for example, “control of the research process”, “basic physical requirements”, “ability to focus on the work”, et cetera); then, the connections between codes were analyzed (for example, connection and similarity of the role of different physical features of a place); and, finally, the larger themes and concepts were drawn (such as these categories: Comfort, Instruments and Diversity). The coding was performed manually, because the amount of materials allowed doing so. It shall be also noticed that there are two types of codes: pre-set codes (usually identified based on theory) and emergent codes. As long as coding is an iterative process, new codes usually emerge during interviews. In this research, main pre-set codes were related to definitions of creativity (and the final analysis of the definitions was done according to these codes) and association groups of creative climate. However, the final model proposed in the thesis was a result of emergent codes.

Theoretical saturation relates to two procedures: the coding of data (when the codes are no longer reviewed) and collection of data (when new data does not bring further illumination onto the concepts). In this research, the coding was done throughout interviews to identify new codes and refine interview questions; and the final review of codes was made upon finalization of all the interviews. As for data collection, during the final interviews, it was noticed that the data and answers in the last interviews only support the proposed model and, thus, the interview process was stopped.

As long as it is necessary to compare the codes from different interviews to identify similar patterns, constant comparison of data is an intrinsic aspect of qualitative data analysis. The same technique was utilized in this research as well. The interviews were compared with each other throughout the whole interview process, which allowed modifying the interview questions so that to analyze in detail new emergent codes and categories. The author's memos supported this process.

After the coding, the new model was formulated, the validity of which was assessed with an expert during the next stage. As for further data representation, several facts shall be clarified.

"Many qualitative studies provide a detailed account of what goes on in the setting being investigated. Very often qualitative studies seem to be full of apparently trivial details. However, these details are frequently important for the qualitative researcher, because of their significance for their subjects and also because the details provide an account of the context within which people's behavior takes place" (Bryman and Bell 2011, 403).

In empirical part, the discussion of results is supplemented with a lot of quotes so as to provide natural verbatim answers of respondents. These detailed quotes allow researchers to present their findings more vividly and support statements; therefore, this technique is also used in this thesis.

Finally, the data analysis used in this thesis was done in accordance with the established rules and this research does not violate the principles of qualitative research method.

3.2.2 Secondary data and its analysis

Secondary data is data collected from secondary sources - sources which contain data collected and compiled for another purpose. Secondary data may be divided into the following categories: documentary (written and non-written materials), multiple source (area based – books, journals; and time series based – statistical

reports, et cetera) and different types of performed surveys (Saunders, Lewis and Thornhill 2009) Although secondary sources are diverse in their nature, they possess some common features such as: they are readymade and readily available; they have data over which a researcher does not have control in terms of collection and classification; and they are not limited in time and space meaning that a researcher does not need to be present where and when they were gathered (Krishnaswami and Satyaprasad 2010). The main disadvantage of using secondary data is that it may not meet the specific needs of researchers; therefore, it is usually necessary to collect primary data. Moreover, usually secondary data is not up-to-date and obsolete to a certain extent, which can be a potential source of low reliability of findings.

Main sources of secondary data collection were electronic information resources and databases provided on a free basis for its students by Graduate School of Management, Saint-Petersburg State University. The following electronic information sources were used most frequently: EBSCO, Elsevier, Emerald, JSTOR, Taylor&Francis, Wiley Interscience, Springer Link, Ebrary Academic Complete and Books 24*7. Additional information was also found on the Internet via using Google Scholar and Google search platform. The orientation of authors towards digital secondary data is explained by the fact that this type of information is newest and updated regularly, which allows to gain an access to the latest scientific and practical materials.

The theoretical themes which were searched for during literature review are presented in Figure 4.

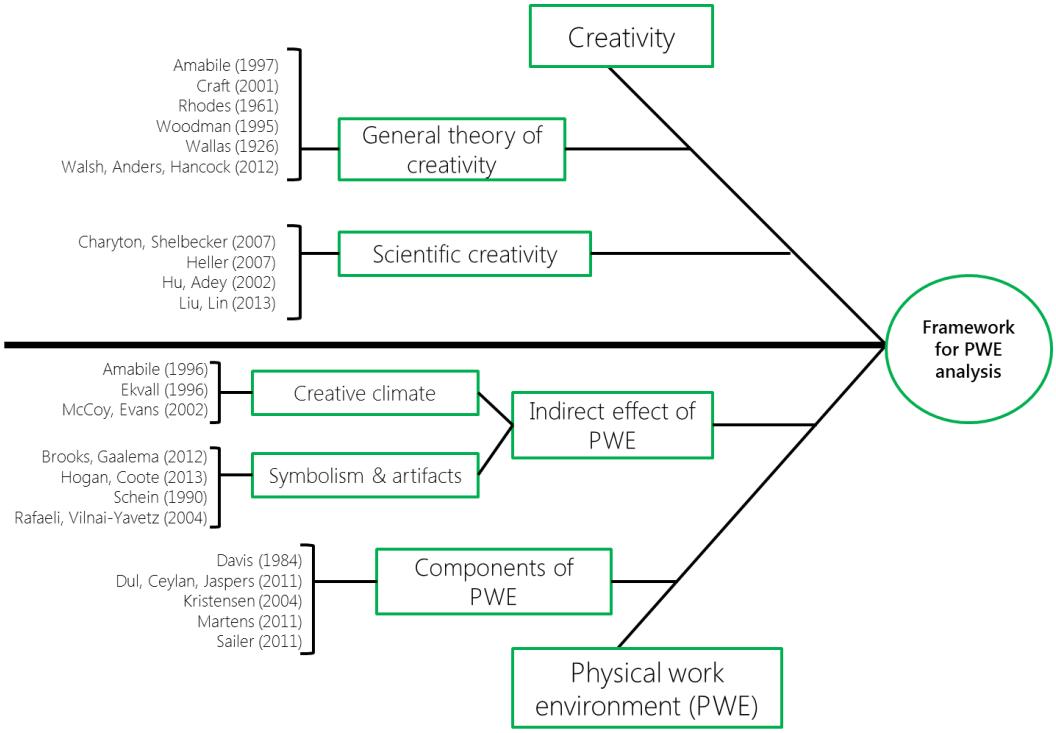

Figure 4: Visualization of theoretical concepts used in Master's thesis

There are two main threads in this research: creativity and physical work environment influencing creativity. In the creativity section, the general concepts of creativity as well as the specific concept of scientific creativity were studied. In the physical work environment section, the main physical attributes were identified for further analysis (and these elements were included in the questionnaire) and the information about how physical environment can indirectly influence creativity was checked with the investigation of such notions as creative climate, physical artifacts and their symbolism. In the end, this literature analysis allowed generating a theoretical framework and a summary table of physical characteristics which were used for further research.

3.3 Limitations of research

As it is mentioned in the beginning of this chapter, every research method has its drawbacks. Among main limitations of the qualitative method are external reliability and validity (generalization), and internal reliability.

External validity is an assessment of whether the results could be applied to other contexts situation and to what extent it may be possible (Quinton and Smallbone 2006). Or in other terms, it is a question whether the results are generalizable to a larger context. This is an obvious limitation considering the micro-orientation of the qualitative method. Usually the sample in a qualitative research is not big enough to make conclusions about larger populations. Thus, this is a natural limitation of this type of research and shall be taken into consideration when making final conclusions.

As for internal validity or reliability of a qualitative research, it is thought to be subjective and it has a lack of research transparency (especially, during coding and analysis stages). This human factor can affect not only the results (its interpretation), but also the process itself (structuring and quality of questions). This drawback was overcome in our research by the following strategy: a thorough preparation for interviews and the coding process via analysis of appropriate literature to learn the best research techniques and implementation of method triangulation (usage of multiple research methods to answer the same question). In this research, three methods were combined: interview, questionnaire and observation, which allowed providing more reliable findings and results.

Thus, this Master's thesis is not a subject to research method violations and the results shall be deemed reliable and consistent.

4 EMPIRICAL FINDINGS

In this chapter, the empirical findings of our research are presented. The chapter is structured in the following way: first, researchers' view on creativity and its relationship to scientific work is shown, the features of the physical environment most important for scientific creativity are analyzed. Finally, the connection between creative climate and physical environment is discussed with the proposition of the new model, which is followed by analysis of Expert's comments about this framework.

4.1 Scientific creativity: definition and restrictions

It is important to understand how researchers view creativity and its connection to scientific process, because it directly influences their perception of scientific creative process, and, thus, the role of physical environment in it.

4P model by Rhodes (1961) was used for the definition analysis. An open-ended question about the definition of scientific creativity was included in the questionnaire and respondents were also asked about the understanding of scientific creativity during the interviews with a series of related questions.

In Table 14, the structured final results with the examples of answers are provided. It shall be noted that some respondents gave several definitions of scientific creativity, thus, their responses were counted in several definition categories.

Table 14: Definitions of scientific creativity according to 4P model and frequency of references

Definition according to 4P model	Example definitions	Number of questionnaire respondents (out of 12)
Person	"Capability to create new knowledge, new forms of its presentation to learn new research methods…" "Capability to find research gaps, challenge	6

Definition according to 4P model	Example definitions	Number of questionnaire respondents (out of 12)
	assumptions, use methods and insights…” “Ability to find something that will be interesting for everyone…” “Capability to create new theories…”	
Product	“New ideas” “New models”	6
Process	“Reconsideration of the existing theories” “Search of new information, new knowledge…” “Critical evaluation of the existing theories” “Formulation of a project idea, formulation of an idea about the project methods…”	5

It is obvious from the table that scientific creativity is a multi-dimensional phenomenon; this was also highlighted by one respondent, who said that he is not able to give a single definition of scientific creativity due to its multi-sidedness. But generally, researchers mostly see creativity as a product (knowledge) with two features: newness and usefulness, which are also described in the literature on creativity. Thus, we may state that scientific creativity follows the general description of creativity, but it deals with a specific product – knowledge.

There are also several specific dimensions of scientific creativity which were discovered during the research:

1) Respondent 9 emphasized not only the out-going side of scientific creativity (in the form of new knowledge), but also in-coming side (in the form of researchers’ ability to learn new research methods).
2) Product of scientific creativity does not mean only a single idea, but it can also be a series of ideas, from which one most prominent idea will appear.

Scientific creativity is "*definitely a process, because, probably, not only one idea appeared, but several ones and, probably, that idea that appeared at first then was transformed into another idea in the thinking process… This is a development process, a process when different ideas appear, not a single one…"* (Respondent 7)

3) Intensity and type of creativity. Generally, it was noticed that some researchers only view creativity in its Big-C form (which means a new break-through idea), whereas creativity also has small-c form, which is not that prominent, but related to the everyday scientific activity. For example, even though some processes do not seem to be creative, there is certainly some small creative part in it.

Even taking as an example a process of reviewing literature, *"one person will only type in some keywords in Google or EBSCO or some other database and the papers will be shown, while other will think further where else he or she can find interesting literature…"* (Respondent 12) This serves as a good illustration of the fact that every step of research process, even a seemingly routine one, requires, at least, a bit of creativity from a scientist.

Respondent 11 noticed that every stage of the research process has, in a sense, its own type of creativity. *"The nature of creativity changes over the project… First, you have to get an initial idea for a paper, that's one sort of creativity… when you start planning your empirical work, it requires a different type of creativity… when you analyze the data and start writing a final report, you also have to be creative, but in a very different form"* (Respondent 11).

Although it is non-deniable that creativity changes greatly in its intensity and nature during the research process, it is useful to differentiate at least two types of scientific creativity: so-called Einstein creativity (creativity of generating new ideas, theories and so on) and work creativity (creativity used throughout the research process). Moreover, as it was found out during discussions of the opposite to creativity concept – work routine, scientific routine processes can be

reduces or eliminated in some situations. For example, as Respondent 9 pointed out: *"…upon developing certain skills, routine processes may be reduced. When you do your base in SPSS for the first time, it may take several hours; for the second time, the very same may be done in half a time…"* And it is also known that a researcher may outsource some tasks (for example, doing interview transcripts or data collection), if resources allow. This routine task outsourcing may make the researcher's work to be centered only on creative tasks. Respondent 13 noticed: "*Currently we do not even do researches by ourselves. We find a provider and if there is enough money, they will do the research for us… (We mostly) generate research ideas and then analyze them*". Overall, this distinction influences the way how scientific creative process is perceived, the model of which is presented in Figure 5.

Considering the importance of creativity for scientific work, 11 out of 13 respondents gave the answer "Strongly agree" to this question with one respondent giving an answer "Agree" and one other respondent chose 3 on the scale from 1 to 5, explaining his answer by the following fact that *"scientific activity should be accompanied by creativity… but talking about the intensity of creativity, creativity is not the most critical factor for scientific activity"* (Respondent 10). In this sense, the distinction between different types of creativity shall be brought up again and, in this case, it seems that the respondent mostly defines creativity in its "Einstein form". However, other respondents also pointed out to the fact that creativity is not the most crucial component, though a necessary one. To quote Respondent 3, *"scientific work is creation of new knowledge and, thus, if you want to create new knowledge, you must always come up with new ideas… If you do not produce anything new, it means that you will not be creative and there is no sense to be involved in science, because science is, by definition, something new".*

In this matter, some respondents share the idea that a successful scientist does not imply to be a creative person. According to Respondent 13, there are some reproductive researches: "*There are some people who do write good scientific work, but they are not creative… (The work) is in accordance with journal*

requirements, but it does not produce something new… so an article is not a synonym of creativity". The question of whether scientific work can be considered a fully creative activity is a tricky one. As it was outlined in the theoretical discussions of scientific creativity, there are, at least, two dimensions to scientific creativity: quantity and quality of articles or other written work. But it is known that there are high requirements to be published in a journal and although the idea of a project may be not novel, probably there are some new methods used to justify the undertaking of this project. Overall, this question may be addressed with the notions of Big C and small c creativities: scientific job implies a piece of novelty in it, but this novelty can differ in its intensity and area of use (for example, it can be either generation of creative ideas or process-type creativity).

In the discussion about interconnection of creativity and science, it is important to notice that, comparing to some art work, there are some limits imposed on scientific creativity. Scientific creativity should serve some purpose (usually, to advance knowledge) and, thus, it is client-oriented (either client being a journal or Ministry of Education) and the client establishes some rules for doing research. Many respondents pointed out to many standards inherent to doing and then reporting researches, which are concerned not only Big-C scientific creativity *("A new idea which is not possible to blend into existing concepts or paradigms will have a little chance to appear in papers…"*, Respondent 5), but also with small-c creativity *("there are also strict tradition how to present research. This is a small thing, but if you are good at building your reports in a way that makes them compelling to read for any reviewers… it may help you. So, in a sense, adhering to some limits, traditions may help you to get forward…"* (Respondent 11) At the same time, it may be perceived as a natural limitation, which probably exists in every field; there are many known example when a piece of art or literature was not accepted for a long time. At the same time, creativity is almost always judged by the outside clientele if not used for personal reasons only. Respondent 11 stated: *"I think that within each discipline there are certain limits that you need to adhere to… if you want to publish of course… but I do not really see these things as restricting creativity. They just give a general frame within which you are expected to be creative…"*

Considering limitations for creativity, there are not only limits on intrinsic creativity, there are also limits connected to resources. This issue is generally discussed in terms of time and financial resources and this research uncovered the same problems. External barriers for researchers' creativity may have different forms: language barrier and a need for a professional translator, financial barrier and grants, time barrier (including so-called long review period and, hence, the data obsolescence), plus some non-formal rules (for example, a co-authorship agreement, when research will not be published unless having some particular person in co-authors). It was not aimed to provide the full list of possible limitation for scientific creativity in this research, but the current list already posits a big challenge to researchers' creativity in general and, mostly, for work creativity.

Getting back to scientific creative process, visualization of this process was developed based on the interviews and it was also found that this model of scientific creative process is highly applicable to analysis of physical environment. The new element which was not highlighted in the literature is presence of writer's blocks, which has direct consequences for organization of workplace.

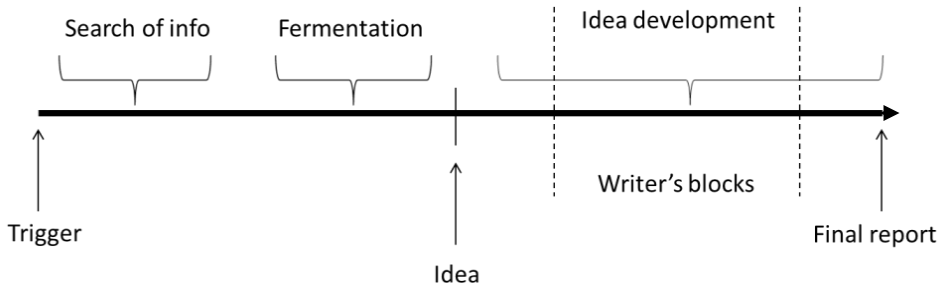

Figure 5: Model of creative scientific process

This description of scientific creative process follows the general established pattern (preparation, incubation, illumination, verification) with some modifications. First of all, three creative milestones are distinguished: trigger (some fact, event or interaction with colleagues which set in motion the thinking

process), idea (as a pretty clearly formulated thought, model or theory) and then final report (in its written form). These milestones divide creative process into separate time intervals and are useful to designate distinct stages. Preparation and incubation are described as search of information and fermentation in the new model. The stage of fermentation deserves an emphasis as a stage when thoughts are processed unconsciously and may produce some output in any moment, so-called Aha-moment. Verification is a stage of idea development with several sub-stages, such as data collection, data analysis and so on. It was decided not to divide this stage further for the sake of simplicity of the model, but these sub-stages are implied. And throughout the idea development stage, there can be writer's blocks (one or several times depending on a scientist), which happen at unpredictable points of time. This model is very useful for analysis of physical environment and its influence on scientific creativity and is used later in the chapter.

4.2 Physical environment and its effect on scientific creativity

Physical environment is a factor to what initially people do not pay much attention unless it is not strikingly inconvenient. Thus, two questions about this factor (with different wording, but the same meaning) were included into the questionnaire. Some respondents noticed that the questions are, as a matter of fact, the same, but, in some cases, answers on these questions differed, which shows a bit inconsistency of opinions among some participants. However, this fact only served as a proof that physical environment is not an obvious factor related to creativity and needs further investigation.

Despite some differences between two similar questions, it may be concluded that respondents agree that physical environment influences their creativity in some manner. The distribution of answers to these questions is shown in Table 15.

Table 15: Distribution of questionnaire responses to Questions 1 and 2

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Question 1*	-	2	1	6	4
Question 2	-	1	3	7	2

*Question 1. Physical environment influence my scientific creativity.

** Question 2. My scientific creativity varies depending on different physical space I work in.

To understand better which factors of physical environment have more influence on scientific creativity, the respondents were asked to specify how strong they agree (on a scale 1-5) that some characteristic differentiate the most creative place. As long as there are 28 characteristics and answers vary a lot in terms of its intensity (for example, agree and strongly agree), only the distribution of answers among characteristics for which respondents choose either “Agree” or “Strongly agree” options are shown in Table 16.

Table 16: Importance of different physical characteristics for scientific creativity according to questionnaire results

Characteristics	**% of respondents**	
A room with only FEW people	*100%*	Comfort and instruments
Multiple technologies	*92%*	
Possibility to personalize workplace	*92%*	
Presence of windows and pleasant window view	*85%*	
Appropriate sensory features (temperature, air quality, humidity, etc.)	*85%*	
Absence of noise	*77%*	
Multi-functionality of a place (with spaces for multiple activities: reading, talking, formal meeting, etc.)	69%	
Size of a workplace	69%	
Visual attractiveness	69%	
Multiple work surfaces (for ex., big table, whiteboards, Post-It notes)	69%	

Characteristics	% of respondents
Easiness of access or movement to any place or destination	62%
Balance of private and communal places	62%
Flexibility and modifiability of furniture and workplace	62%
In-house services (sport facilities, food service, etc.)	54%
Enough ergonomic furniture	54%
Distinct sense of style and design in a place	54%
Multiple non-technical resources and tools (for example stationary)	46%
No video surveillance	46%
Décor (paintings, art items, etc.)	38%
Plants, flowers and sense of nature	38%
Gaming and recreational facilities	31%
Natural building materials (for example, wood)	31%
Colorful place	15%
Equality of workplaces to those of my colleagues	15%
No segregation of work facilities and people (by research interests, status, etc.)	15%
Direct visibility of work station	15%

According to the table, it may be seen that all the features were deemed important for creativity by, at least, some respondents; though some characteristics were identified by most people. The characteristics identified by more than 80% of respondents are underlined and analyzed in detail onwards.

Presence of few people and absence of noise are mostly connected to the fact that scientific work is an intensive process which requires concentration. If you lose concentration, it may be difficult to get back to work and, thus, you need to start all over again; therefore, you lose time or may even lose some thread of ideas.

As for appropriate sensory features, they are important for, at least, two reasons:

1) These factors may be a huge distractor:

Respondent 2: *"There are some factors that kill creativity in the bud: for example, cold or some wind from the window. Or just any distracting factor of the physical environment, it pulls all your attention and you cannot concentrate on work";*

Respondent 9: *"This is the worst place to work (due to the fact)… that in wintertime it is very cold here. It is very uncomfortable and you want to get out of here at the earliest possible opportunity".*

2) Scientific work is an intellectual act, therefore, when a person feels some discomfort, it may impede some intellectual or cognitive ability of that person.

Windows play almost the same role as sensory features, because natural light create a comfortable ambience and, moreover, it helps to relieve some stress or tension.

Respondent 10: *"It is ideal if you can also look at a window or if there is a nice view on the opposite… so that you can give some rest to your eyes and to change the focus a bit. When you look at a window, it helps to reduce stress connected with immersion into materials or a problem, and then you come back to computer it is already easier to continue working…"*

Technical instruments are vital for scientific work per se. The current technologies give scientists a vast array of possibilities to do research work. There are online databases so that you do not need to go to the library as in the previous times, there are online communication tools to collaborate with your co-authors, there are programs (both for quantitative research, such as SPSS software, and for qualitative one, such as tools for analyzing transcripts or visualizing concepts in the form of MindMaps). Therefore, they are indispensable part of creative work, especially on the stage of idea development and search of information.

As long as every person has a different working style, personalization allows creating the place which will be most beneficial for a particular person. This issue is explored in detail in the next sub-chapter.

Overall, some components of the environment are important so that a person was able to basically work, and some other components, such as flowers, pieces of arts, may exist, but they are more individual requirement rather than general. More analysis of these characteristics follows, because they were highlighted in the theoretical literature, but did not receive much support from the respondents.

Talking about these peculiar components of the physical environment, such as color scheme of a place, or some visual attractiveness, or design, which do not play neither instrumental nor comfort-creating role, respondents did not emphasized them. Moreover, several respondents said that the best color for a work space would be white or something neutral or calm (for example, beige), because: 1) it does not distract, 2) it allows for better customization of place. Secondly, some design may be burdensome, demanding and uncomfortable for work due to its grotesqueness.

Respondent 2: *"When there is a lot of artwork, it is also (emotionally) difficult… it creates some tension… I prefer places with simple design, without additional pathos so that the environment does not demand anything from itself, but it would be pleasant to be there. Something homely… unstrained, non-binding…"*

Last of all, art forms follow the same logic as design. According to Respondent 8, *"there can be some art objects, but pretty unobtrusive, non-bright…"*

Considering some nature elements, flowers were not a distinct requirement for the physical space. Some respondents pointed out that it is benevolent to have something connected to nature, but rather in a form of parks than in the form of flower pots in a room. And it serves the purpose to relax and to switch off your attention from some troubling work issues.

Several additional components not mentioned in the table were also identified: tea kettle or/and vending machines and scientific written materials (books and articles). The first component is discussed later in the chapter. And as for books or articles, they are usual elements of the scientific work at the first sight. However, by asking respondents about how much and for what purposes they use books or articles or even other written materials which are usually present on a table (or in the form of notes on whiteboards) in vast amounts, it was found that for some respondents these objects serve a greater purpose rather than reference materials. Books or articles, or to be precise, the amount of those, may signal to the owner how much work shall be done, or help put the owner in some work mood.

Respondent 11: *"(Written materials) create an atmosphere of having a lot of projects going on… It serves as a kind of to-do list; so by seeing the pile, you remember all the projects you should be thinking about…."*

Respondent 4: *"In order to engage myself in this open (work) mode, I need artifacts related to my profession, such as printed articles, some drawn models hung at the office, some notes… it creates a feeling of completeness of the place and focus on what I am doing…"*

It was also observed that many respondents found it difficult to choose the exact parameters that define the creative space. Therefore, generalizations about particular features could not be made based on these answers, but as it was noticed, the upper elements in the table pertain to categories of comfort and instruments. And the updated model of physical environment (provided in the final sub-chapter) use these categories to assess a place for its creativity support.

4.3 Physical environment and creative climate

In the previous sub-chapter, physical environment was analyzed in terms of its direct effect on scientific creativity. In this sub-chapter, physical environment is discussed via its indirect impact, or its symbolic aspect, in particular. It was initially hypothesized that, by creating a particular atmosphere, physical environment conveys some message to occupants of this place and, thus, affects

their creativity. This research was partially aimed to check whether it is possible to draw some connections between physical environment and creative climate.

The distribution of answers to the questionnaire questions is shown in Table 17 and their subsequent explanation follows.

Table 17: Distribution of questionnaire responses to Questions 3 - 7

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Question 3	-	-	1	8	4
Question 4*	-	3	2	4	2
Question 5	-	1	1	6	5
Question 6	2	2	2	5	2
Question 7	1	1	3	6	2

*Question 5: Number of respondents out of 11, because this question was included into the questionnaire after the second interview.

List of questions:

Question 3. Physical environment creates a special mood or atmosphere at my work place.

Question 4. My perception of a work place is more or less stable and is not prone to changes.

Question 5. I would describe the place where I feel most creative as supporting diversity of opinions and initiatives, stimulating new ideas and as a place which provides time and resources for my creativity.

Question 6. I would describe the place where I feel most creative as dynamic with a sense of playfulness, humor and liveliness.

Question 7. I would describe the place where I feel most creative as engaging and with a sense of meaning and challenge.

It is clear that all respondents support the idea that physical environment does create a certain atmosphere at a place, but the perception of this atmosphere may differ for some respondents. As a result of our analysis, it was understood that these changes shall be attributed mostly to the social phenomenon - people who are also present at this place and can influence its image in the eyes of other occupants of the same workplace. Thus, it may be supposed that the changes of

perception differ among people: in more social-oriented people, the perception of a place can vary significantly, while more self-centered people do not pay a lot of attention to what type of people surround them in work environment or, at least, it does not change their perception so drastically.

Respondent 4: *"The peculiarity of our office is that people are constantly going in and out… that's why it is difficult to concentrate and to give a way to your creativity. In these situations I put on headphones… Without headphones it is not comfortable, with headphones it is more comfortable, but not as much comfortable as if people just did not communicate with me for some time… for example, if until 6 o'clock when my colleagues are at the office, you do some routine tasks, after 6 o'clock, the office becomes empty and it is possible to do research work".*

This quote exemplifies how people can make some place comfortable or non-comfortable and how it may impact your work schedule as well, if there are no other coping mechanisms to deal with the problem of social distraction.

In most part, respondents also agree that the creative place is connected with such notions as Support, Dynamism and Engagement, but there is a variation of answers on this issue. However, what does not allow drawing definitive conclusions and connecting the elements of creative climate with physical environment is that respondents interpret these notions differently, though general trends of interpretation are identified and presented in Table 18.

Table 18: Comparison of interpretations of symbolic elements used to assess physical environment

Element	Negative interpretation	Positive interpretation
Support	-	Certain physical elements create an internal confidence in scientific activity and that it is welcomed at a place (for example, technical equipment, work surfaces); Diversity of places as opportunity to

Element	Negative interpretation	Positive interpretation
		do different kind of work is also seen as support.
Dynamism	During the very act of doing research (literature review, data analysis, etc.), a researcher is not in movement, but rather in a stationary position.	An ability to change place at will during different stages of research process; Freedom of movement around the place and access to some public places where people can gather.
Engagement	Obliging space can be too overloaded (with people, with meaning, etc.), work is expected at such a place, but the atmosphere itself is not conducive to scientific creative work.	A place which oblige you to behave in a certain way or to act specifically (library as a place where it is expected to work and not to relax); A place which stimulate engagement with an idea, internal mood and perception of an "inviting" place; A place where you get motivation and new ideas, with a lot of people (and interaction with them can lead to joint projects).

The table serves as an obvious visualization of differences in interpreting the symbolic items among respondents – the fact which does not allow identifying clear connection between physical artifacts and the symbolic role they have. Some respondents could not even relate physical environment to these elements, interpreting them as factors of organizational culture (for example, support as an acceptance of failure at an organization). This type of interpretation is similar to the socio-psychological model of creative climate. One respondent even chose the option of "No associations" for every item when matching physical attributes with three associative groups – Support, Dynamism and Engagement. Thus, empirical results do not provide support for the symbolic model of physical environment.

The results of matching physical characteristics to the association groups are nonetheless shown in Table 19 (distribution of answers is counted out of 12 respondents, excluding one respondent who chose no associations with physical attributes). And despite the aforementioned lack of unity of interpretations about the association groups, some physical characteristics tend to be allocated to the same association group by many respondents.

Table 19: Distribution of responses connecting symbolic elements with characteristics of physical environment

Characteristics	Support	Dynamism	Engagement	No or other association
A room with only FEW people	2		**8**	2
Multiple technologies	7		5	
Possibility to personalize workplace	4	4	4	
Presence of windows and pleasant window view	2	1	**8**	1
Appropriate sensory features (temperature, air quality, humidity, etc.)	4		2	6
Absence of noize	2		**9**	1
Multi-functionality of a place (with spaces for multiple activities: reading, talking, formal meeting, etc.)	5	3	4	
Size of a workplace	2		6	4
Visual attractiveness		5	5	2
Multiple work surfaces (for ex., big table, whiteboards, Post-It notes)	**6**	3	3	
Easiness of access or movement to any place or destination	1	**7**	1	3

Characteristics	Support	Dynamism	Engagement	No or other association
In-house services (sport facilities, food service, etc.)	4	5	2	1
Enough ergonomic furniture	**6**		3	3
Balance of private and communal places	4	1	6	1
Distinct sense of style and design in a place	1	3	**6**	2
Flexibility and modifiability of furniture and workplace	3	**6**	3	
Multiple non-technical resources and tools (for example stationary)	5	1	2	4
No video surveillance	1		3	**8**
Décor (paintings, art items, etc.)	1	4	4	3
Plants, flowers and sense of nature	1	5	3	3
Gaming and recreational facilities		**10**		2
Natural building materials (for example, wood)	1	1	5	5
Colorful place		**9**		3
Equality of workplaces to those of my colleagues	2		5	5
No segregation of work facilities and people (by research interests, status, etc.)	**6**	1	3	2
Direct visibility of work station	3		2	**7**

To identify the cases in which the relationship between physical characteristics and the association groups are more or less common, the following check-point rules were utilized:

- More than 50% of respondents shall agree on this association,
- The next association shall be less than a half than the principal association.

The characteristics which adhere to the aforementioned rules are written in bold.

Such characteristics as existence of few people in a room, absence of noise, and presence of windows contribute to the place which attracts the respondents as comfortable to perform scientific work in. Multiple work surfaces (such as big table, whiteboards and so on) signify that the work is welcomed here and these are the integral attribute of a work place, basically. Easiness of access of movement to any place or destination is obviously connected to Dynamism, because easy wayfinding allows changing places easily and without additional effort. Enough furniture is a necessary component to perform work, thus, the existence of it shows support for scientific activity. Design and style of a place may serve an engaging role: if a place is designed in some particular way, it may put a person in a certain mood. Modifiable furniture again allows changing a person's position, which surely can be attributed to some form of Dynamism. As for gaming and recreational places as well as colorful room, they are a representation of liveliness of a place, the characteristics which was included in the notion of Dynamism. And the associations for both of these features were chosen almost unanimously. What is interesting here is that video surveillance seems to be not important and does not convey any particular message to respondents, while in the theory it was thought that this very attribute serves as a demonstration of an organization's openness to diversity of ideas (in the case when employees are trusted and allowed to behave at their will without much control). Direct visibility seems not to have any significant meaning as well.

Finally, it may be seen that there is a possibility to find associations between different physical attributes and factors of creative climate, but, probably, the

reliability of these associations is not that high, because people's perception of these elements differs. Thus, the conclusion may be drawn that physical environment certainly possess some symbolic meaning about creative climate, but it cannot be generalized from the current findings. This does not allow creating a unified symbolic model of physical environment and necessitates other framework to assess its relation with scientific creativity.

4.4 Physical environment and scientific creativity: model for analysis

As long as the previous model based on creative climate was not considered to be viable for analysis of physical environment, during interviews a different recurring (in almost every case) pattern was found. When asked to describe the attributes of the ideal creative place for scientific work, the respondents replied in a surprisingly similar way with only slight differences. The composite description of the ideal place is presented below:

The ideal place has comfortable furniture, reliable computer with all the necessary accessories (the Internet, software and alike), light (preferable natural from windows) and a place which allows you to choose your own working mode throughout the research process.

This definition in combination with other probing questions laid a foundation for a two-tier model of analysis shown in Figure 6. There are two level of analysis: Comfort and Instruments belong to the first level, whereas Diversity is attributed to the second level. First category is Comfort and some physical features that play this exact role in the scientific process are furniture, sensory features and so on. Second category is Instruments (technical and non-technical) without which the research tasks cannot simply be performed. And the final element is Diversity of a place. In the current literature, an accent is already made on the fact that the work space shall have a balance of private and communal places (which was also an element of the questionnaire), but in the new model, this feature plays a larger role. Diversity embraces the concept of freedom to choose between different

separate geographical places (such as home, office, park, public places as café, et cetera).

This framework was developed based on both theory and empirical research. The main concepts (Comfort, Instruments and Diversity) were identified by means of performed ground research. The particular physical characteristics attributed to these categories were found during the literature review. However, new physical elements (which are written in bold) were identified during the interview process. The distinction between creativity and productivity level is an outcome of both theoretical and empirical research. The lack of clear distinction between these levels in the literature prompted corresponding interview questions, the answers to which helped to find a way to differentiate these concepts. The detailed description of the model follows.

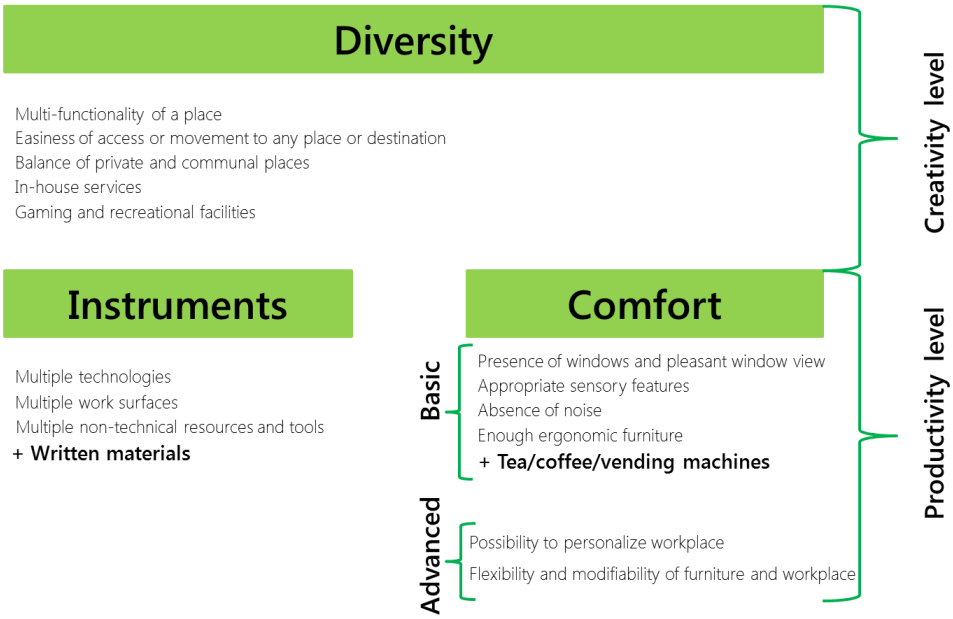

Figure 6: Framework for analysis of influence of physical environment on scientific creativity

On the bottom level is Comfort, which is one of the primary components necessary for any productive work. If a person does not feel comfortable, if something irritates him or her, it would be almost impossible to concentrate on a task at hand. If we imagine the situation that there are a lot of instruments, but no place to sit and to work or if it is extremely hot in a room, it would not be possible

to do any scientific work. When asked about the preferred place to do research in, many respondents said that this place is associated with comfort and coziness in their mind. But as long as the question about comfort arises, there are always personal differences in understanding the concept of comfort. Therefore, comfort can be achieved via two steps: satisfaction of basic needs (such as pleasant sensory features, efficient work station) and a possibility for personalization and modification.

When asked about modifications they do to their work stations, the respondents' answers differed to a great extent. It is possible point out to the most striking differences and themes:

- Organization of the table:

Respondent 5: *"If there are piles of paper on the table, some chaos, it would be uncomfortable for me… if everything will be clean, a lot of spare space, I would be more creative, because the mind will be free of all this information and it would be easier to concentrate on something particular";*

Respondent 9: "*I like to lay round myself different materials and, overall, I like a big table so that it would be enough for all books to lie onto…"*

- Formal versus informal work station:

This issue can be implemented to analysis of different components: choice of work station (office versus home), decoration of work station. Considering choice of work station, some people find it difficult to concentrate at home, because it can be a bit relaxing atmosphere; while for some a homely and undemanding atmosphere create a sense of comfort and even protection.

Respondent 6: *"At work if someone passes by, you pay attention to who it is; at home you feel confident, because you know that even if someone passes by, it is a family member and you can ignore this fact…"*

Respondent 9: *"Of course, it is more pleasant to write (a research paper) at home in the calm atmosphere… on the other hand, home entices you to relax. At work you feel more collected and you write more intensively…"*

Considering some decoration of place, some people may have some small gifts (such as figurines) at their work station because they are just "*pleasant to eyes and memorable souvenirs*" (Respondent 9), while some people prefer to stick to no-frills work stations: *"(there are only items) related to work on my table…. I don't like when there are these (casual) things at the work station, they take away attention, in some sense*" (Respondent 6).

In conjunction with comfort, one peculiar question shall be discussed as well. When describing which factors are most important for creative scientific work, many respondents mentioned a possibility to drink tea, existence of vending machine or a teapot at their individual office. This fact was important both for doing research individually and for joint projects, because *"it is cozier (to have a discussion with a colleague) with a cup of tea rather than without it, and at the big table on a sofa…"* (Respondent 10) As long as food and drinks are at the first level of Maslow's hierarchy of needs, this fact can also be categorized under basic requirements. Moreover, it was found that tea/coffee is a good companion when doing research, because it relaxes a person and makes him or her less tense, it creates this sense of "the homely place" or, at least, a sense of comfort, the concept mentioned by many respondents. Therefore, it is highly advised to have tea/coffee equipment and vending machines at the offices.

The next element on the bottom level is Instruments and here again there is no particular standard how technically equipped a work place shall be. Based on the interviews, two user types can be defined: users with average intensity of technology use and people with advanced requirements. The second variant may be explained by many factors: a work style of the person (usage of some additional programs or tools), predisposition to using technologies, et cetera. As a confirmation and illustration of this category, two quotes are provided below.

Respondent 12: *"(All I need to do research) is a computer on the laps and that's it".*

Respondent 7: *"(I have) a whiteboard at my workstation where I put my notes…I have three computer monitors…because for (my style of work) it is important to have spacious work surfaces…"*

Instruments also include other physical attributes, such as non-technical resources and multiple work surfaces. The intensity of their usage is also dependent on a person, but all but one respondent answered that they need quite a big table (either to spread papers around, or to put elbows on it to feel more comfortable, or for some other reasons). However, the most significant elements of this notion are still technical resources (a well-working computer and the Internet).

One more additional element to this category was found: written materials as the instrument to control the work process and a personal tool for scheduling and tracking the work tasks. Although, these materials are not particularly necessary to perform research, they play an instrumental role in the scientific creative process and, thus, were allocated to this category.

The final element and the most significant one for scientific creativity is Diversity of a place. If the first two elements can be considered productivity elements to a certain extent, Diversity is directly connected to creative activities. To visualize this issue more clearly, we provide a depiction of scientific creative process accompanied with notes in Figure 7.

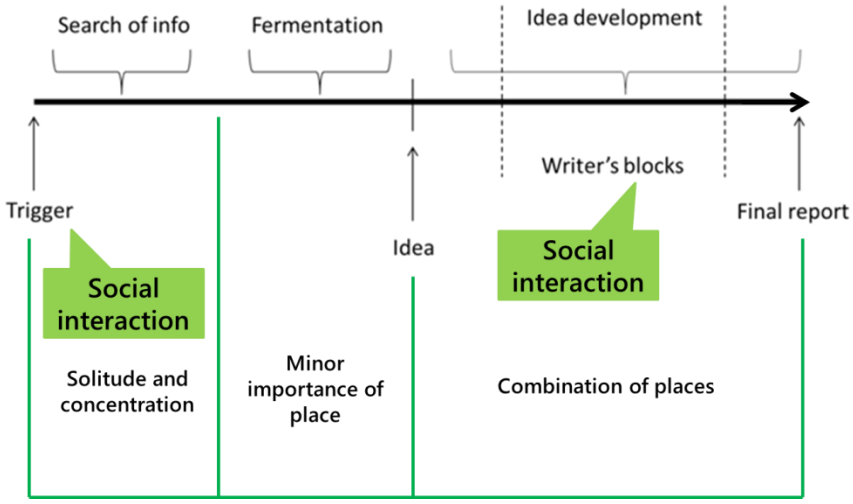

Figure 7: Diversity of places on different stages of creative scientific process

First of all, the respondents were asked about how they get new ideas for research. Although there are, at least, two possible ways: it can be either an individual act of discovery (when reading some article, book, or even sources on the Internet and mass media) or a collective act (for example, during conferences speakers' ideas might lead to your personal ideas, or exchange of information may lead to joint projects); the respondents emphasized that communication with colleagues or environment is vital for ideas to appear.

Respondent 6: *"…So that new interesting idea may appear, there shall be some experience anyway, or even not an experience, but a person shall be exposed to certain environment, which will attract attention to itself".*

The initial trigger is usually followed by a time of individual exploration. A person tries to understand the phenomenon more deeply and to gather more information about it to have a clear picture of it in mind. In other words, the person tries to clarify if there is anything worthwhile about this idea or it does not worth further attention. During this stage a person shall be allowed to be on its own and, in some cases, even at some third space places (neither work nor home) just to have a legitimate time to think, free from some work or home duties.

Respondent 8: *"When there is a time to think… to brood over something for a while… then new ideas come up, which you can view at a different angle and to do something differently…"*

After this stage comes a period of fermentation, when a person processes information subconsciously. This can lead to appearance of a new idea for research, or it can end fruitlessly, because in the end, *"…many of research ideas you get, they are not that good after all, so you end up just deleting it, sometimes you can start drafting something based on it and then decide 'Ok. That was not really a path to take' and sometimes you just leave it aside right at the beginning…"* (Respondent 11) At this stage, because the processes are uncontrollable, the place is not that important comparing to other stages of the scientific creative process.

Next and the longest stage is idea development. It was already mentioned that this stage consists of several sub-stages, the description of which is out of the scope of this research. However, exactly this sub-categorization requires different types of environment. It depends on a personality of the person, but it is common that at some point of time, a researcher needs some private space; at other times, he or she needs a communal place to meet with colleagues; at some other moment, some distraction places may be needed (for example, shops, restaurants, parks, et cetera). Here it is useful to quote Respondent 11, whose example perfectly describes this diversity phenomenon:

"The exact places depend a lot on the mood… I like reading outside (when) I have to get this overall perception (of the phenomenon/topic) in a not completely quiet and separated space for that, but to have something going on around you so you do not feel like you are buried in the books… For running data analysis, I need this ability to really concentrate on it and be careful about each step I take… then from home I do quite a lot of actual writing, I need my laptop and rather quiet space".

The issue of mood and its connection to scientific creativity and any other type of creativity shall be studied more thoroughly in conjunction with the topic of diversity of places, but it is also not in the scope of this thesis.

The topic of writer's blocks is one of the major ones in terms of diversity of places. When asked about the usual way to overcome writer's blocks, the respondents mentioned different details about their techniques. However, it turned out that in order to get over this situation, they just need to have rest from their research for some period of time. It can be a holiday, a social place, such as café, or a place in university to talk to colleagues but on a different topic. Strange as it may be, but researchers need to leave aside the topic and thoughts about it for a while (supposedly, for some more round of fermentation) to get the solution or proceed further. And, at those times, the possibility of changing a working place matters a lot.

So Diversity of places is a requirement for scientific creativity, which is prone to mood swings. And this concept embraces not only the question of private-communal places, but it is a larger concept of *"being in charge of everything that happens"* (Respondent 11), of *"acting as you wish at the necessary moments from your needs' perspective"* (Respondent 9), and of "*regulating your life as you need… this is absolute freedom which gives you an opportunity to embody it in some (scientific) products*" (Respondent 13). This concept is not that obvious to the researchers themselves, but several respondents answered the interview question about the ideal place for scientific creativity in the way similar to the description of Diversity category:

"I cannot say that this is one place. Like if you gave me this place, I would write that number of articles per year. Perhaps, there is no such notion as one ideal place" (Respondent 8), but rather it is a combination of places which correlated to the needs of researchers at different stages of research process.

One more question, which appeared during the evaluation of importance to change places throughout scientific process, is the tendency of some universities

to build their own out-of-city campuses. The characteristic of physical environment “Easiness of access or movement to any place or destination” reappeared at another angle during the interviews. It can be perceived not only as an easy wayfinding inside a building, but as a possibility of movement to different places inside a city (home, parks, social places, et cetera). When the campus is out of the city, it impedes this possibility to change places that easily; this can lead to the situation when professors who do research will go to universities only on days of their lectures and the research itself will be done from home. However, as it was shown, communication between colleagues may give rise not only to joint projects, it can also help in some writer’s block situations and the exchange of opinions also benefits everyday scientific creativity of every interlocutor (for example, getting to know new methods or techniques used in the researches of fellow scientists). At the same time, it may be said that there is still a possibility to go to meet colleagues; nobody restricts the right to do so. The issue is that this choice about places shall be really given several equally attractive options. There should not be dominant and dominated strategies, if talking in the terms of game theory; then Diversity will be ensured.

Lastly, not all elements were found to fit into the proposed model (for example, such attributes as visual attractiveness, plants and items of nature, few people in a room were left out), because they do not have a clear role in terms of their influence on scientific creativity. Considering visual attractiveness, décor, plants and so on, some people welcome it, while some do not; and none of the respondents also mentioned that these features can be a source of comfort for them either, thus, these characteristics were left ungrouped. Such elements as size of a place or direct visibility were not emphasized by respondents at all, which is also obvious from Table 18. And such elements as “Few people in a room” cannot be qualified to any category as well, because the creative process requires both privacy and community elements (as it is shown in Figure 7). Thus, not all elements are present in the final model.

Finally, the new model is not completely different from the initial model which was proposed based on the creative climate considerations. Support is somewhat

related to Instruments, which signify that the work is welcomed here. Comfort creates a place to which researchers want to go, which can be called Engagement in some sense (moreover, some interviewees when describing what they perceive as an engaging place named it exactly as comfortable). And Dynamism is similar to Diversity in a sense that it allows a change of places at will. Moreover, the final model with two levels of analysis (Productivity and Creativity levels) was found to remind the two-factor theory by Herzberg (Sachau 2007) and can even be titled the two-level model of creative physical environment. While Comfort and Instruments are usually not sufficient on their own for scientific creativity, Diversity serves as a factor of higher level of importance upon fulfilling the basic requirements, which is similar to hygiene factors and motivators in the two-factor model by Herzberg. These similarities were discovered already after the research was done. The concept of scientific creativity is different by nature and explanation of the levels differs from the model of Herzberg. Therefore, the two-level model of creative physical environment can be considered a separate finding, but the similarities with the established model can serve as a proof for its reliability.

4.5 Model verification: results of expert interview

An interview with an expert was conducted in order to verify the model and to check its generalizability. As long as the expert is always in contact with different researchers, the exposure to their multiple views makes her knowledgeable about the physical requirements necessary for creative and productive scientific work.

First of all, the definition of scientific creativity given by Expert once again highlights the ambiguity of notions “scientific creativity” and “scientific productivity”:

“*Scientific creativity is productivity in the field of scientific research: achievement of certain results, the writing of articles and other publications, participation in conferences, preparation of monographs and case studies*” (Expert).

Considering the compiled list of physical characteristics used in this research, the expert's opinion was as following:

"The list of factors seems more or less exhaustive and there are indeed a lot of factors" (Expert), by which a physical place may influence scientific creativity.

The main factors, which are especially taken into consideration when constructing the work place of researchers, were not specified, but the strategy seem to be more general and the whole phenomenon is considered in its entirety rather than in the form of a check list of characteristics.

As for the final two-level model of creative physical environment, Expert gave a high evaluation of the model and admitted its good representativeness of the reality. However, there are two comments considering the applicability of the model.

First comments relates to the fact that for some researchers (especially, those from natural sciences), the relevance of Diversity category may be of less or even zero importance.

"*Diversity may be neglected by some researchers who are deeply in science only due to the fact that their consciousness is entirely in the problem they are investigating… the rest of the world does not exist for them, because they live in their separate illusory world… they are constantly in their thoughts*" (Expert).

The second comment is about cross-country differences. And the two aspects were mentioned in relation to this issue: socio-economic level of country prosperity and cultural national differences.

It was suggested that there can be differences between developed and developing countries considering researchers' needs about the physical environment. The case of Graduate School of Management was given as an example. Some foreign professors require different working physical conditions, because they are accustomed to higher standards (in most cases, professors come either from

Europe or the United States). At the same time, according to Expert, Russian professors do not actively show their preferences.

There are also differences in working styles among countries and that can be also reflected in the requirements about the physical place which will allow creative scientific work.

Considering the symbolic aspect of physical environment, it was said that Graduate School of Management tries to stimulate discipline in its walls and, thus, use some physical artifacts such as program brochures in the corridors (which remind of the high status of University) or written materials (articles, books, working papers in showcases or in other form) in offices and research centers to "*put researchers in a working mood*" (Expert).

Overall, the model was deemed to be useful for analysis of connection between physical work environment and scientific creativity and productivity. And the comments about the model were used to evaluate delimitations of the findings and suggestions for future research.

5 FINDINGS AND CONCLUSIONS

This chapter summarizes the main findings of this research linking together the empirical results and theory. The answers to research questions and sub-questions are explicitly stated. Theoretical and practical contribution of this research is discussed. In the end, delimitations and suggestions for future research are outlined.

5.1 Main research findings

As a result of this research, several findings can be drawn, which help to answer the main research question.

First of all, considering definition of scientific creativity, the empirical study shows that this notion is still identified in narrow terms in most cases. Many researchers still view creativity as something groundbreaking and not as something incremental. Although the literature distinguishes different types of individual creativity (Craft 2001; Kauffman and Beghetto 2009) which can vary in its intensity, this distinction is not a widely known fact in the real life and, thus, this put some limits on the ways in which creativity can be stimulated. As long as researchers perceive creativity only in its Big C form (which is harder to train and manage; and which is unique to a personality); they do not utilize all the methods and techniques to nurture other types of creativity smaller in scale but more applicable in professions. Moreover, the scientific creative process is not understood to the fullest degree by practitioners themselves and, in most of the cases, creative process is identified only until the point of illumination, while there is a continuation of that process afterwards (Wallas 1926). Therefore, this limited understanding of creativity may pose some consequences for researchers' creativity due to the fact that it is difficult to manage some phenomenon properly when the existence of this phenomenon is not known or understood. If researchers were fully aware of the notion of creativity, they could have adopted new practices or tools to better manage their creative capabilities.

The next finding comes directly from the previous one. Many interviewees pointed out that they did not even perceive or think about particular physical factors which affect their creativity and, thus, they did not attribute a lot of importance to physical environment in relation to their scientific work. Although when asked directly about this phenomenon, many researchers provided some interesting revelations about the way (and particular physical characteristics) in which physical environment influences their scientific creative performance. In general, physical environment was evaluated highly in terms of its influence on creativity and, hence, requires attention both from management of universities and researchers themselves.

Considering physical characteristics most important for creativity, the following elements received most support: quite a detached room without many people and, thus, absence of human noise (which was found to be the most distracting noise for scientific work, while some non-human background noise can be even beneficial in some situations) and multiple technologies. These factors are also highlighted in the theory (Sheykhan and Saghaee 2011; Oksanen and Stahle 2013), while other factors which were found to be of high importance – factors of well-being (window view and appropriate sensory features) are not well articulated in the literature. Although some authors (McCoy 2005; Dul and Ceylan 2011) as well as consulting reports (GSA Office of Governmentwide Policy 2006) include these factors in their models, they are not given that much importance which was revealed in this research. The last component – possibility to personalize the workplace is also a bit downgraded and under investigated in the theory, but it was rated high by the interviewees.

Some most frequently discussed physical characteristics – layout and visual aspect of physical environment (attractiveness, décor, presence of plants and so on) – were found to play a role for creativity, but to a lower degree. The idea proposed by Haner (2005) that attractive place is mostly defined in terms of being stimulating and inspirational rather than in simple terms of possessing some specific physical features (such as intricate and complex design) is supported by

the interviewees who mentioned that a place shall simply be comfortable to work in and, thus, attracts to perform scientific activities there.

Some new elements were identified which are usual and non-obtrusive on the surface, but play an important role in scientific creative process – tea/coffee and vending machines; and written materials at the work station. Their role is explained by their categories Comfort and Instruments in the final framework developed to assess influence of physical work environment on scientific creativity.

Support for the indirect (symbolic) aspect of physical environment was not discovered. Although some physical elements are possible to attribute to certain association categories, the difference of associations' interpretation did not allow drawing final conclusions on that issue. However, this serves as one more proof for the idea of Kristensen (2004) that physical environment has both objective and subjective sides, where symbolism belongs to the second type. Probably, the difficulty to study subjective opinions about symbolic physical artifacts explains that not a lot of research has been done on that issue so far.

Considering the lack of an established model that incorporates all the details linking physical environment and creativity (Sailer 2011), the main result of this research is the framework developed to assess a role of physical environment for scientific creativity. The framework is depicted in Figure 6. This two-level model was developed separately from theoretical models of the organization motivation theory, but, in the end, it is thought to be reminiscent of two-factor theory of motivation by Herzberg in terms of its factor differentiation.

The physical characteristics which belong to the categories Comfort and Instruments are factors of the first level. They do not stimulate creativity per se, but they are usually necessary for the presence of creativity. They are also named productivity factors, because they were very frequently mentioned in their connection to scientific productivity by the interviewees themselves. For the easiness of analysis, they are divided into two categories: Comfort and

Instruments. Physical artifacts that belong to Comfort category serve to ensure the well-being of researchers. However, as long as people's need differ, there are two level of comfort as well: the first level is general needs (and the next attributes follow under this criterion: appropriate sensory features, ergonomic furniture, presence of windows and so on) and the second degree of comfort can be achieved via catering to specific needs of each person (with the possibility to personalize a workstation and modifiable furniture). Instruments are those physical artifacts necessary to perform a task. The need for instruments can differ as well, but, generally, they are technological equipment, work surfaces and non-technical tools.

The factors of the highest second level pertain to Diversity category. Due to the changing needs (mostly, in terms of interaction and privacy) of researchers throughout the creative scientific process, diversity elements ensure that these needs are satisfied and, therefore, they contribute to scientific creativity. The idea about space diversity is not completely new and was encountered in multiple sources (Haner 2005; Sailer 2011; Martens 2011), but it was not clearly stated or even mentioned at all that this diversity implies not only spatial diversity within one work environment (for example, a workplace building), but a more general diversity with the meaning of having access to a multitude of geographical places. The diversity of this higher degree allows researcher to act on their creativity needs. In some cases, these needs may not be perceived by researchers themselves (for example, a necessity to talk to a colleague, who can help with a research in some way) and this spatial diversity might play a serendipitous non-detectable role.

Finally, some authors constructed their models as two-level frameworks (Oksanen and Stahle 2013), but they did not explicitly state the difference between the two levels of analysis. Secondly, these levels of analysis were formulated in vague terms and differently from the terminology and its meaning used in this research; in addition, the number of factors taken into analysis was considerably fewer. Moreover, there have not been encountered a work comparing the theory of influence of physical environment on creativity to the Herzberg's two-factor

theory, which was shown to be useful to implement in similar studies. However, the new two-level model of creative physical environment shall not be considered purely an extension of Herzberg's model, but a separate finding due to the different distinct phenomenon of analysis and interpretation of two levels. The question of adequacy of the model was checked with an expert and the model was deemed appropriate and useful for analysis of the connection between scientific creativity and physical environment.

5.2 Summary and discussion

5.2.1 Summary of findings

The spread of technologies and other external factors are changing the role of physical work environment from being a purely place to perform a work to a place which can serve a larger role, for example, to minimize hassle so that employees have more time for creative thinking (Florida and Goodnight 2005) or to encourage serendipitous interaction and, thus, flow of ideas (Walker 2013). These changes of the modern physical work environment are driven partly by changes in workforce. The knowledge workers come to the forefront of a company's success in the knowledge economy and companies respond to their changing workplace needs. Researchers are obvious representatives of this worker type and, therefore, were chosen as a unit for analysis.

As long as there have not been found a framework for holistic analysis of physical environment in its connection to scientific creativity, the main research aim was to build a model for analysis and find out how to assess influence of physical work environment on scientific creativity. The exploration of existing models and concepts was made during the literature review and the main conclusions for the theoretical analysis was a summary table of all physical characteristics which are thought to influence creativity. The number of these characteristics totals at the point of 28 features. The main theoretical streams to connect physical environment and creativity were divided into three categories: analysis of physical environment as a set of characteristics, interaction models explaining how

physical environment affect communication and privacy in work settings and, in turn, creativity, and last – symbolic role of physical work environment. However, there is no established framework in each of these categories; the less studied category was the last one.

The literature (Kristensen 2004; McCoy 2005 and others) suggests that physical characteristics of the work environment can convey a certain symbolic meaning to employees – occupant of these work places. Thus, initially, the research tried to establish the links between association groups (composed from the Ekvall's model of Creative Climate Questionnaire) and physical characteristics of a place.

The main research method was interviews accompanied by qualitative questionnaire. This method was chosen due to the exploratory aspect of this research and qualitative research is thought to suit best the necessity to form a deep understanding of the unfamiliar phenomenon (Bryman and Bell 2011).

The initial hypothesis about the symbolic aspect of physical environment was not supported by research findings due to the differences of individual interpretations of association groups, which deemed the results non-comparable. The subjectivity side of symbolism is also highlighted by Kristensen (2004) and the findings serve as an additional proof for that. However, the interview method allowed creating a framework to study relationship between physical environment and creativity - the two-level model of creative physical environment. The main research conclusion from this model can be formulated in these terms: there is no one single creative place that can satisfy all the creativity needs, but it is rather a harmonic combination of several places, which, in total, can help creativity to flourish.

5.2.2. Theoretical implications

The first theoretical contribution of this thesis is the thorough summary list of factors to analyze physical environment from the perspective of creativity. The current literature puts emphasis on different physical aspects and attributes, thus, there is no unified model to study these two concepts – creativity and physical environment – together. This research summarized all the factors found in the

existing literature into one table (Table 12), which allowed seeing the issue of connection between physical environment and creativity in a broader context and building a comprehensive framework for analysis.

The aforementioned two-level model of creative physical environment is the second contribution of this research. This model has two categories of physical characteristics on the first level – Comfort and Instruments – that serve as "hygiene factors" for creativity, while Diversity category of the second level is a "creativity stimulant". This approach to divide the analysis of physical environment into two levels (productivity and creativity) is one of the theoretical novelties of this framework. The broader definition of spatial diversity is included in the notion of Diversity (in comparison to the existing literature), which can be considered the second novelty.

To support the idea about diversity of places as a necessary requirement for scientific creativity, the revised version of scientific creative process was also developed. Some new elements were introduced, such as writer's block, which were omitted in the previous models of creative process. As long as people and researchers differ in their need for social interaction, this fact can undermine the requirement of diversity of places based solely on the distinct stages of creative process (which necessitates communal and private places). However, the existence of writer's blocks, which is thought to be inherent for scientific work (and creative work, in general), serve as one more strong proof for a diverse work environment that can support creativity.

5.2.3 Managerial implications

Considering the practical contribution of this research, it provides managers with some guidelines about the way they could support and stimulate creativity of knowledge workers (and especially, research workers) by means of physical environment.

The final model of the scientific creative environment highlights the fact that there are several physical features necessary for creativity. In this sense, two

categories – Comfort and Diversity - shall be emphasized. As long as higher level of comfort can be achieved through personal modifications to work places, it is advised to allow for personalization of work stations. Such techniques as hot-desking, when employees do not have their own work place and can work at different places day after day, seem not to support creativity at work. Second issue is that such elements as vending machines, coffee or tea pots can enhance the perceived comfort of a place; thus, creativity can be partially supported at work by equipping workplace with such amenities.

The creative place or environment is an aggregative phenomenon, therefore, it is recommended to ensure the diversity of work places. The issue of working hours is thought to be of high importance in such discussions: flexible working hours can allow employees to be in charge of their schedule and workplace, which will help them to attain the workplace diversity suitable for their needs. Moreover, proper management of working hours of different employees (especially, in the case of open plan offices or workplaces where several employees work in one space) may also provide better conditions for creativity (by establishing appropriate levels of interaction and privacy). If it is not possible to provide employees with private work stations, it is recommended to allot one separate workplace (a room) to employees with different work schedules so that each of them can have, at least, some time and place for seclusion at work and the possibility for concentration and convergent thinking.

In the end, there can be some considerations concerning understanding of creativity. As long as creativity and creative process are not understood to the full extent, it can be advised to provide some creativity trainings or workshops at work. As a result of these company initiatives, employees will learn how to manage their creativity and will take notice of the factors relevant for their own creative capabilities. In turn, they will be able to express more distinctly their needs about the work station that will support and enhance their creative performance; these suggestions can be employed by companies afterwards.

5.3 Delimitations

As it was shown in the methodology description, every research method has its own disadvantages. Talking about the disadvantages of this research due to its qualitative nature is that the sample is quite limited and confined to the researchers of Graduate School of Management (Saint-Petersburg State University). Therefore, this fact can have consequences for results and their generalizability, in particular. However, this sample was large enough to draw conclusions and achieve the research goal; therefore, it did not impede the research process itself.

There are also several considerations in terms of sample structure. Although one foreigner was interviewed during the research and the results were comparable to those of Russian-speaking respondents, the cross-cultural differences can also be an issue. Thus, the results better suit the Russian experience, while other countries can have their own peculiarities in relation to this issue.

The second point about the sample structure is that only researchers of social sciences were interviewed, while it can be a case that researchers of natural sciences may have a different perspective on this issue. We may suppose that Instruments may be of higher importance for them in terms of productivity; but talking about scientific creativity, Diversity of places is still supposed to be the most influential force in supporting scientific creative process, so the final model will probably stay the same. However, this delimitation with researchers of difference science types shall also be admitted.

5.4 Suggestions for future research

In this final section, suggestions for future research are provided and they can be divided into two types: suggestions for future research to overcome the outlined delimitations and suggestions for future research in terms of its research direction.

As for suggestion for future research due to the delimitations of the current research, sample size may be increased and more diverse group of researchers

shall be included in this sample, considering not only their science specialization, but also national and age status. This will help to achieve more generalizable conclusions and test the final model of creative physical environment.

As for the second type of suggestion, a new model to study the symbolic aspect of physical environment can be devised. Or, probably, some modification to the current model may be enough to achieve this goal. These modifications may concern the wording of the association elements, more detailed explanation of the elements to respondents and so on. Providing that the final framework – the two-level model of creative physical environment – was developed based on answers from the academia, this model can be checked on researchers and other knowledge workers in the corporate settings. This type of research will allow to study the phenomena on a grander scale and to achieve even more managerial implications.

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APPENDICES

Appendix 1: Questionnaire “Scientific creativity and physical environment”

This questionnaire is conducted as a part of Master's Thesis titled "Symbolic aspect of physical artifacts conducive to scientific creativity" (Ekaterina Afanasyeva, a student of Double Degree program GSOM SPbSU-LUT). The time for filling it out is estimated to be approximately 10-15 minutes. The anonymity of all responses is guaranteed and the received information will be used only for research purposes. The aggregated results will be also delivered to the GSOM Administration for their further consideration. Thank you very much for taking part in this research!

Creativity is an important part of scientific work.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

What definition would you give to scientific creativity?

Physical work environment influence my scientific creativity.
(Physical work environment is a set of physical characteristics of a work place, such as windows, illumination, furniture, etc.)

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

My scientific creativity varies depending on different physical space I work in.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

The below mentioned characteristics differentiate the place most conducive to my scientific creativity.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Easiness of access or movement to any place or destination	○	○	○	○	○
Multi-functionality of a	○	○	○	○	○

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
place (with spaces for multiple activities: reading, talking, formal meeting, etc.)					
In-house services (sport facilities, food service, etc.)					
Enough ergonomic furniture					
Gaming and recreational facilities					
Balance of private and communal places					
No segregation of work facilities and people (by research interests, status, etc.)					
Size of a workplace					
Absense of noize					
Colorful place					
A room with only FEW people					
Appropriate sensory features (temperature, air quality, humidity, etc.)					
No video surveillance					
Multiple technologies					
Direct visibility of work station					
Visual attractiveness					
Natural building materials (for example, wood)					
Decor (paintings, art items, etc.)					
Distinct sense of style and design in a place					
Equality of workplaces to those of my					

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
colleagues					
Flexibility and modifiability of furniture and workplace					
Possibility to personalize workplace					
Plants, flowers and sense of nature					
Multiple non-technical resources and tools (for example, stationery)					
Presence of windows and pleasant window view					
Multiple work surfaces (for ex, big table, whiteboards, Post-it notes)					

Physical environment creates a special mood or atmosphere at my work place.

	1	2	3	4	5	
Strongly disagree						Strongly agree

My perception of a workplace is more or less stable and is NOT prone to changes.

	1	2	3	4	5	
Strongly disagree						Strongly agree

I would describe the place where I feel most creative as supporting diversity of opinions and initiatives, stimulating new ideas and as a place which provides time and resources for my creativity.

	1	2	3	4	5	
Strongly disagree						Strongly agree

I would describe the place where I feel most creative as dynamic with a sense of playfulness, humor and liveliness.

	1	2	3	4	5	
Strongly disagree						Strongly agree

I would describe the place where I feel most creative as engaging and with a sense of meaning and challenge.

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Please, specify which characteristics of a workplace you associate with which place description.
(For every characterteristic, choose one most appropriate description, please)

	Diversity of opinions, support of initiatives, resources and time for new ideas	Dynamism, liveliness and playfulness	Engaging place, meaning and challenge	None or other associations
Easiness of access and movement to any place or destination	○	○	○	○
Multi-functionality of a place (with spaces for multiple activities: reading, talking, formal meeting, etc.)	○	○	○	○
In-house services (sport facilities, food service, etc.)	○	○	○	○
Enough ergonomic furniture	○	○	○	○
Gaming and recreational facilities	○	○	○	○
Balance of private and communal places	○	○	○	○
No segregation of work facilities and people (by research interests, status, etc.)	○	○	○	○
Size of a workplace	○	○	○	○
Absense of noize	○	○	○	○
Colorful place	○	○	○	○
Room with only FEW people	○	○	○	○
Appropriate sensory features (temperature, air	○	○	○	○

	Diversity of opinions, support of initiatives, resources and time for new ideas	Dynamism, liveliness and playfulness	Engaging place, meaning and challenge	None or other associations
quality, humidity, etc.)				
No video surveillance				
Multiple technologies				
Direct visibility of work station				
Visual attractiveness				
Natural building materials (for example, wood)				
Decor (paintings, art items, etc.)				
Distinct sense of style and design in a place				
Equality of workplaces to those of my colleagues				
Flexibility and modifiability of furniture and workplace				
Possibility to personalize workplace				
Plants, flowers and sense of nature				
Multiple non-technical resources and tools (for example, stationery)				
Presence of windows and pleasant window view				
Multiple work surfaces (for ex, big table, whiteboards, Post-it notes)				

Identification questions

Please, identify your work status at the University.

- ○ PhD student
- ○ Senior lecturer
- ○ Associate professor
- ○ Full professor
- ○ Other: _____

Please, identify your gender.

- ○ Male
- ○ Female

Please, identify your age category.

- ○ 20-29 years
- ○ 30-39 years
- ○ 40-49 years
- ○ 50-59 years
- ○ 60 and more years

Please, identify your scientific tenure.

- ○ Less than 1 year
- ○ 1-5 years
- ○ 5-10 years
- ○ More than 10 years

Approximately, how many different workplaces have you experienced so far?
Any places where you were doing some scientific work (including home)

_____

Would you like to receive the results of this research?
(The results will be sent to your e-mail after finalizing this research)

- ○ Yes
- ○ No

Appendix 2: List of interview themes

1. Definition of scientific creativity and its importance for researchers
2. Nature of scientific creativity (process or point in time, et cetera)
3. Creativity: attitude in science, limitations for being a creative researcher
4. Creative places: where new ideas come to mind most often, where to do a research, et cetera.
5. Most important physical features of creative places
6. Modifications of work places and the reasoning behind it
7. Peculiarities of scientific creative process and physical environment
8. Associations with creative places
9. Thoughts and comments on questionnaire association elements – Support, Dynamism, Engagement
10. Ideal place for scientific creativity