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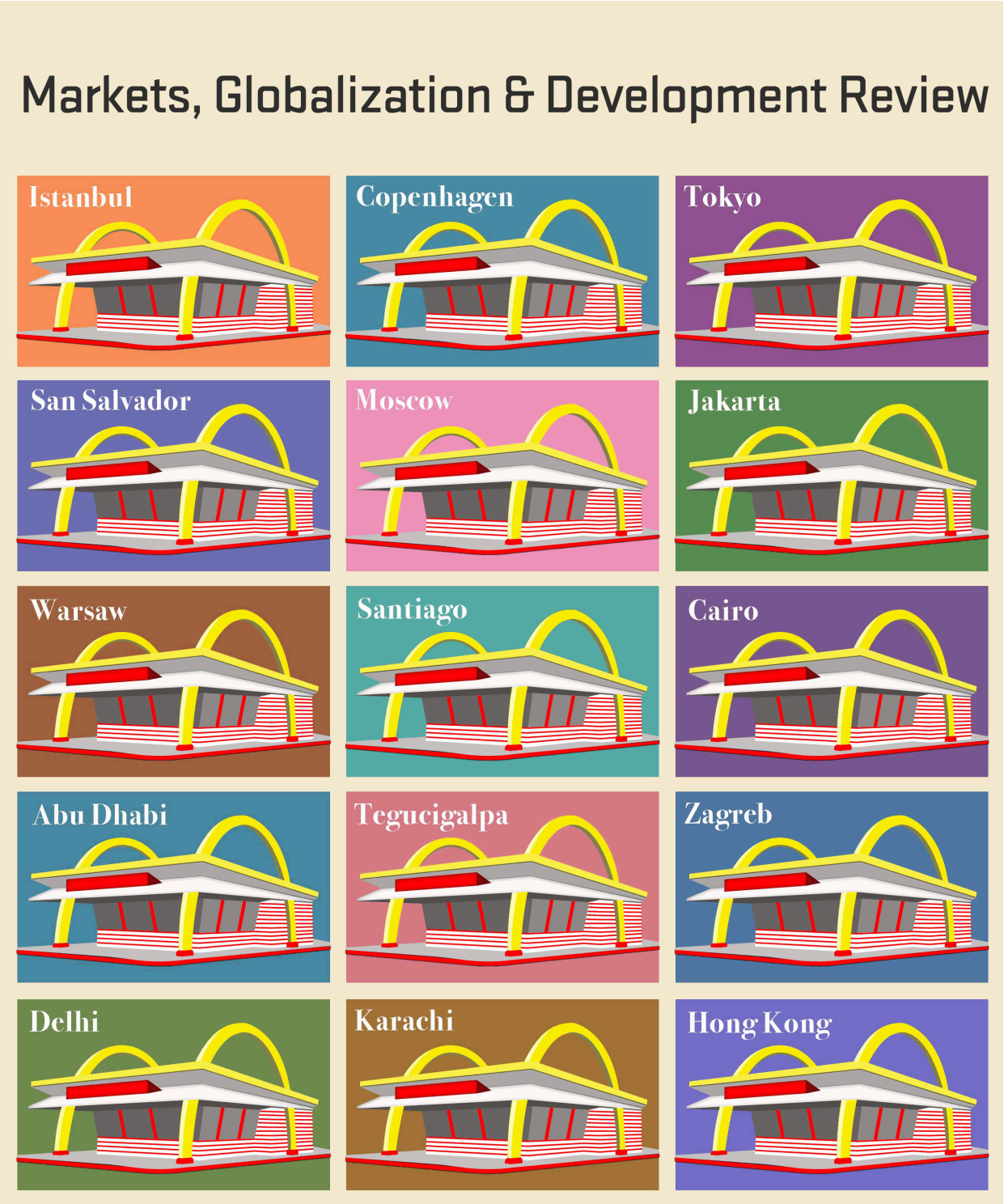


The Potentials of Learning Object Design in Design Thinking Learning

Introduction

The market needs surviving skills such as creativity, communication, collaboration and critical thinking due to the evolving technologies (Gardner 2010, Pink 2006, Wagner 2011). Design thinking is one of the mindsets that can remediate the present and future needs (Meinel et al. 2011; Noweski et al. 2012; Vaganti 2009; Wringley 2015). Education is a tool to gain these skills and raise human resources depending on market needs, therefore; we can assume that design thinking educations and workshops are getting popular and widespread. Design thinking education has skill-based, effective and cognitive outcomes (Taheri et al. 2016) and adopts constructivist learning approach (Scheer et al. 2017). Constructivist learning approach is based on constructing new knowledge on prior knowledge by learners' own initiative (Piaget 1970), the knowledge is gained through individual experience (Fosnot and Perry 1996; Kolb 1984; O'Dennel 2012; Piaget 1970; Reich 2008) by the practitioner's reflections on their own actions (Schön 1982).

The learning process is designed by defining Intended Learning Objects (ILOs), planning Teaching and Learning Activities (TLAs) and evaluating the Assessments (ATs) depending on the constructivist alignment approach (Biggs and Moore 1993; Elisabeth et al. 2009). TLA, which is introducing the learning object (LO) and activities to reach the learning goals, has an essential role in the constructivist learning approach as the knowledge is constructed through this experience (Biggs and Tang 201; Scheer et al. 2017). LOs are all of the digital and non-digital learning materials (LTSC 2000) which are the fundamental parts of learning (Pearson 2016; Polsani 2003). For this reason, LO design is getting an increasing attention day by day with the improvement of learning technologies (Willey 2000). Regarding this perspective, one should ask what the constructivist design thinking education LOs are and how can their properties be described. Is it possible to contribute design thinking pedagogy literature and indicate potential research areas about design thinking learning objects?

This paper focuses on the understanding of design thinking mindset in terms of the constructivist learning process from the perspective of LOs; therefore, firstly the scope of design thinking, design thinking learning and learning object approaches will be described regarding literature research. The design thinking learning objects will be defined and classified by Ritland

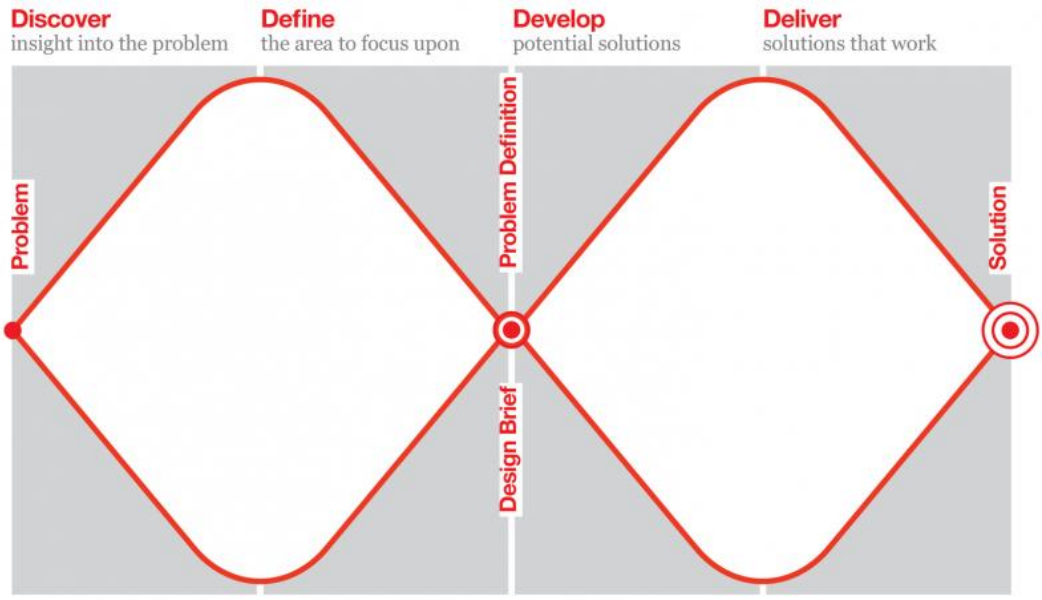
et al.'s (2000) granularity levels. Also, the learning theory and LO relationship will be framed with Bank's (2001) approach to explore the common features of constructivist design thinking LO. In the evaluation part, the research indicates the general properties of LO and potential areas regarding literature research in terms of LO and design thinking learning relationship.

Design Thinking

Design Thinking mindset has framed as a characteristic pattern of thinking in creative industries' design processes (Kelley and Kelley 2013). Design process and the design outputs are innovative, highly creative, cross-disciplinary tool responsive to the needs of human (Papanek 1971). The design problems considered as wicked problems regarding how designers conceive them (Buchanan 1992). The designer is the one who has the creative problem-solving mindset to produce a solution (Cross 2006) who is the synthesis of artist, inventor, mechanic, objective economist and evolutionary strategist who can convert existing situation to the desired one (Buckminister 1956; Simon 1969). Design thinking can be considered as a human instict and everyone experience design process in their daily life (Cross 1983; Kelley and Kelley 2013).

Design process is a procedure from problem definition to problem solution; however, design process phases have various interpretations (Dorst and Cross 2011; Efeoglu 2012; Plattner et al. 2009). It constitutively occurs in two distinct phases; problem definition and problem solution (Buchanan 1992). Design Council describes the Design process in the model of Double Diamond (Fig. 1) which includes Divergent and Convergent parts. Divided into four distinct phases – Discover, Define, Develop and Deliver – the Double Diamond is a simple visual map of the design process.

Figure 1: Double Diamond Model



Source: Design Council

The design process consists of two parts that each includes diverge and converge processes. The first diamond symbolizes the problem definition process and the second one is the idea generation and selection of the solution. Idea generation processes which are defined as ‘'Discover" and ‘'Develop" are spreading approach, and they are accepted as diverge processes. Elimination and choosing processes are converging because the feasible ideas or problems are chosen by elimination. To describe the ‘'Double Diamond" process, the first quarter is defined as ‘'Discover" which is a process to frame the scope in a holistic perspective and notice new things and gather insights. ‘'Define" part is the process of bringing definition to meaningful possibilities from the discovery phase and making the most effective decision for the starting point. The goal here is to develop a clear creative brief that frames the fundamental design challenge. ‘'Develop" stage is where solutions or concepts are created, prototyped, tested and iterated in the perspective of solving defined problems. The deliver phase is the process of verifying the ideas by small tests. The process ends by launching the solid project idea which is an appropriate solution for the defined problems. In sum, the design process determines the problem in the scope of the project from the various alternatives from different perspectives and brings a reliable solution to the project from various ideas (Fig. 1). The design process is metaphorically like as a system of spaces

rather than a predefined series of orderly steps (Brown 2008). Diverging and converging phases in the design process makes the process constant and iterative cycle of problem identification and redefinition (Dolak 2013). Design process is an activator for design thinking (IDEO 2012).

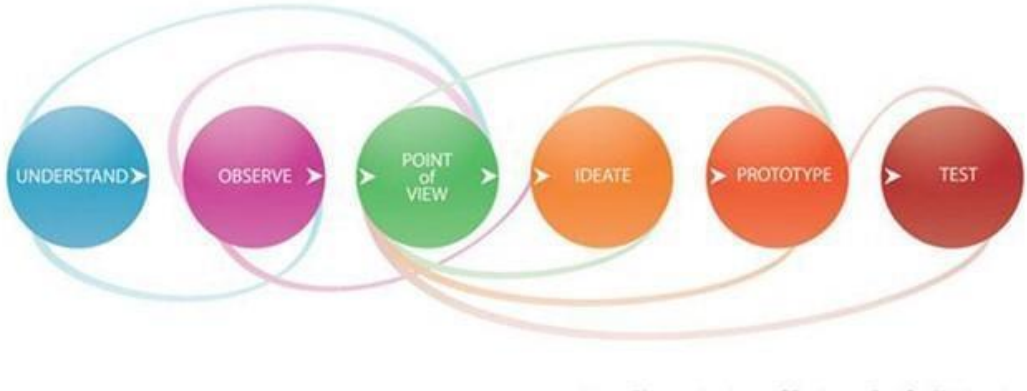
‘’Design thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success (Brown 2009).’’ Design thinking is asking the right question beyond the immediate boundaries of the problem to be solved and questioning the circumstances to gain a holistic perspective (Holloway 2009) which is categorized into sub-discourses as: the creation of artifacts; a reflexive practice; a problem-solving activity; a way of reasoning /making sense of things; the creation of meaning (Sköldberg et al. 2013). This mindset incorporate diversity and leverages different paradigms and tool sets from each profession to analyze, synthesize, and generate insights and new ideas by using interdisciplinary teams (Brown 2009) The multidisciplinary nature of design thinking also ensures that innovations are naturally balanced between the technical, business, and human dimensions (Brown and Katz 2011; Kelley and Littman 2001). In the frame of these explanations, it can come to the inference that the design mindset as thinking path which designers gain by repeating the creative problem-solving challenges. In this context, we can assume design thinking as a mindset that approaches a case with different perspectives in an interdisciplinary manner and brings out creative, feasible solutions to the core of diverse problems. This mindset is framed as a process by the common solution based thinking pattern of the design processes of creative industries (Kruger and Cross 2006). The design thinking is a structured approach to generate and enhance ideas by navigating the process from identifying challenge to finding and building a solution (IDEO 2012). It is a profoundly human approach that relies on designer’s ability to be intuitive, to interpret what designer observe and to develop ideas that are emotionally meaningful to who designing for (Burcahan 1992). Design Thinking as a practice-based activity and a way of making sense of things, design thinking uses deductive or inductive reasoning for problem-solving (Dorst 2011). On the contrary, it is abductive, inclusive and problem-based (Oster 2008). It is described as abductive because it reaches well beyond deductive and inductive reasoning to build up a mountain of possible answers. Design thinking is both a process and a mindset, and it has nine characteristic futures; 1) ambiguity; 2) collaboration; 3) constructiveness; 4) curiosity; 5) empathy; 6) holism; 7) iteration; 8) non-judgmental way; 9) openness

(Baeck and Gremett 2011; Luka 2014). Characteristics of design thinking are defined by Owen (2007) as;

- Conditioned inventiveness -''what'' questions are more important than '' why'' questions as the goal is inventing
- Human-centered focus - the clients' needs have to be taken into consideration by designers when creating a product
- Environment - centered concern to guarantee sustainability
- Bias for adaptivity means applying an approach of accepting adaptive solutions fitting to the users' evolving needs wherever possible
- Predisposition towards multi-functionality as problem-solutions need not be mono-functional Systematic vision as design thinking
- View of the generalist - for inventive creativity, contrary to the accustomed specialization, the wider the knowledge base, the more creative solution can be made
- Affinity for teamwork because multi-disciplinary teams ensure such characteristic abilities as a generalization, communication across disciplines, working systematically with qualitative information and visualizing concepts (Owen 2007)

The iterative design thinking process scheme (Plattner et al. 2009) initially comprised of six stages (Fig. 3). Six stages described as Understand, Observe, Point of View, Ideate, Prototype and Test which is arrayed from left to right in a linear path. The dynamic structure is visualized by linear units that combine different stages. In this context, it is assumed that the design thinking process starts by bringing a common understanding to the scope of the meaning and described by the ''Understand'' phase. The following stage, ''Observe'', is the process of creating empathy with the target group and defined stakeholders by observations and researches. The stage ''Point of View'' is to indicate the problems from diverse perspectives to solve and it defines the direction of the project. The following stage ''Ideation'' brings creative solution alternatives to defined problems at the previous stage by an abstract thinking approach. ''Prototype'' stage is the process of creating tangible models of various ideas to ''Test'' stage to choose feasible ideas in the scope of the project by testing of prototypes (Plattner et al. 2009).

Figure 2: Iterative Design Thinking Process



Source: Plattner et al. 2009, p.114.

In the context, design thinking accepted as a mindset in the aim of defining the problem and bringing creative solutions to the issues defined in the scope of the projects. Design thinking mindset consists of the iterative design process which is an activator for design thinking process (IDEO 2012). This part of this paper includes definitions on design thinking mindset and design processes. This mindset, include active making culture, can be delivered to an individual by different pedagogic approaches that's why the design thinking learning will be framed in the following part.

Design Thinking Learning

The complexity of everyday life is increasing, globalization, fast-changing technological advances, product cycles getting shorter and economic competition tightening, innovative capacities comprised in the 21st century, skills have become crucial for individuals to survive in an ever-changing society (Dikmans 2011). Innovation drives improvement, either incrementally by advancing existing processes or more radically by introducing new practices (OECD 2014). From educational researchers to businesspeople and politicians, society is calling for so-called essential competencies to be able to deal with any complicated problems that dominate all facets of our society and business world (Pink 2010; Gardner 2010). Education can be considered as a tool that can be a fundamental part used by the needs of the business world (Noweski et al. 2012). As do companies around the globe, many educational institutions are required to compete internationally and, therefore, are investing in education systems that emphasize leading through innovation (Beckman and Barry 2007).

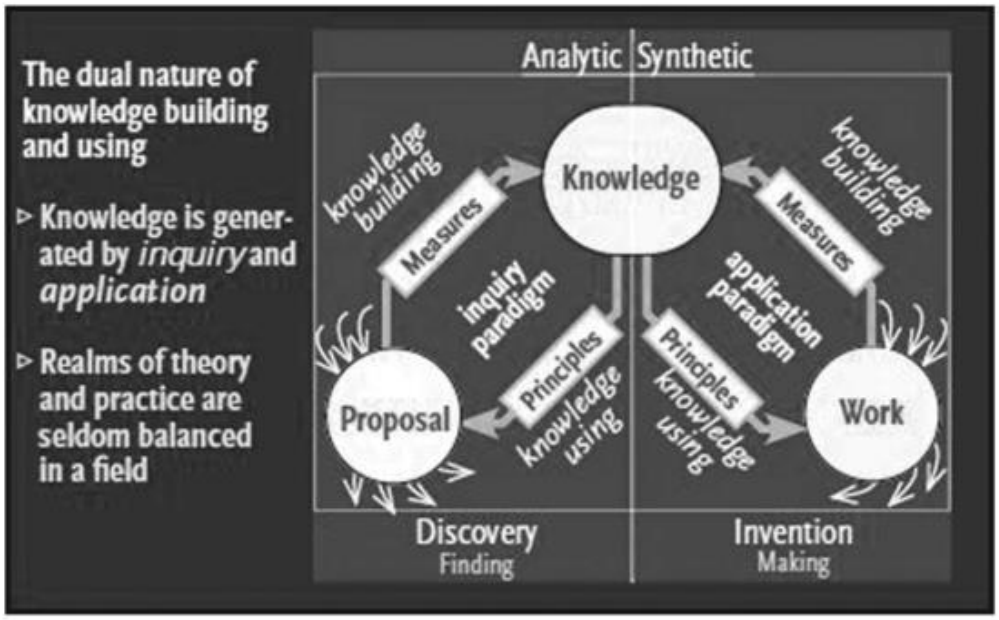
Schools have to aim for each student to improve their character for society, raising responsible and questioner individuals (Scheer et al. 2012). Science, business and social organizations adapts 21st-century skills as critical thinking, collaborations, adaptability, communication, analytic thinking, curiosity and initiative called as seven survival skills for career, college and citizenship (Wagner 2010) Students have problems of working across disciplines, working in different disciplines, and synthesizing different disciplines (Spelt et al. 2009). As education modes are changing from a teacher-led approach (that focuses on content delivery and assessable outcomes), to a learner-based approach (Biggs and Tang 2007), The learner-centered approach, building on students' current knowledge and abilities (Lambert and McCombs 1998), enhances the development of higher-order skills such as critical thinking and problem-solving (Gravoso and Pasa 2008). Design Thinking is a model for enhancing creativity, endurance, engagement and innovation (Dolak et al. 2013). Schön (1982) defines the reflection as the core of learning in design education, and thinking was interpreted as the core of design work and as a part of practice. Reflection is at the basis of learning, and any successful activity and teachers should encourage students to reflect on their actions to come to a solution (Schön 1982). An ideal learning cycle must comprise the following four phases; experiencing, reflecting, thinking and acting, and a learner goes through all of them (Beckman and Barry 2007). Knowledge is generated and accumulated through action (Owen 2007).

> "The reflective practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behavior. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation (Schön 1982)."

Learning is a process of understanding, which leads to modifications in the behavior of the learner (Hasselhorn and Gold 2006). A mindset can be gained by repeated experience process (Biggs and Tang 2011; Dewey 1938; Scheer et al. 2012). Design research develops knowledge in the service of action; the nature of design thinking is thus normative and synthetic in nature—directed toward desired situations and systems and synthesis in the form of actual activities (Fig.4) (Romme 2003). Knowledge using and knowledge building are both structured processes controlled by

channels that contain and direct the production and evaluation processes (Owen 2007).

Figure 3: Knowledge Creation



Source: Owen 2007, p.19, Figure 7

The nature of ‘designerly thinking' has been revealed by cognitive science (Baynes 2006). Design learning as a cognitive orientation to design reasoning as a foundation (Oxman 1999) and the notion of “designerly way of knowing” that identifies how designer holds a distinctive way of thinking (Cross 2006). Thinking like a designer involves different kinds of abilities and competence in different fields of knowledge: conceiving, planning and making products (Buchanan 1999). Correspondingly, designers have a solution-focused mindset rather than problem focused and this mindset consider as an ongoing process which is a transition from abstract level to concrete one (Tovey 2015). Cognitive studies in design education often based on protocol analysis of current teaching methods instead of new teaching approaches (Oxman 2004) such as creativity (Lu 2015), design processes and strategies (Kruger and Cross 2006; Gelmez 2016). The cognitive process in design learning appears by two main intervention (Schön 1982); reflection-in-action and reflection-on-action. ‘'Reflection-in-action'' means thinking on feet; ‘'reflection-on-action'' described as reconsidering the practice later. Design education occurs by iterative action processes, and the learner is a practitioner in that process. In this approach;

the practitioner can examine his/her actions by revisiting them (Schön 1984). Realizing that designing is a cognitive activity that attracts our attention to think and orient design learning from a cognitive viewpoint (Gelmez 2016). Cognitive activities enable the learner to reach a particular goal such as understanding a phenomenon while metacognitive strategies make learners check and confirm if the goal has been accomplished (Livingston 2003).The reflections in the learning process depend on the actions, and the practitioner should learn to frame and reframe the case and plans interventions during the process (Schön 1982). The learning is not only experiential but also process-based rather than being product-based (Dewey 1938). In this context, instructors direct the process by interventions as a master practitioner; handle design problems by using "moves/words" and "demonstrative/descriptions" to transfer the ability of dealing with the probable issues that the novices can undergo and help them while the learner's new ‘making' experience (Walks 2001).

Design thinking education has diverse application in higher education, but there are some related values in the core as; learners and instructors involve the project process as reflective practitioners deals with real life problems in interdisciplinary teams that learning appears by peer learning, initiative, and social interaction (Wrigley 2015). The Institute of Design at Stanford has been improving new models for design thinking (Meinel et al. 2011; Meinel and Leifer 2013). This model applied in the perspective of seven fundamental mindsets; 1) focus on human values; 2) showing not telling; 3) creating clarity from complexity; 4) getting experimental and experiential; 5) being mindful of processes; 6) bias towards action; 7) collaborating across boundaries (Plattner et al. 2009) The criteria for planning design thinking education process is framed as; challenges should be chosen from the real-life phenomenon; the knowledge sharing should be provided by action - interaction balance between learner and instructor; understanding should be constructed by reflection during the problem solving and application of idea processes (Scheer et al. 2012). Design Thinking education enables students to work successfully in multi-disciplinary teams and enact positive, design-led change in the world and it is a problem-solving approach dealing with the solution of everyday problems (Rauth et al. 2010). The design thinking learners are dealing with complex real-life problems by analyzing and evaluating them to act solution-oriented and responsible during their learning processes. Design Thinking realizes what is recommended theoretically in the constructivist theory (Scheer et al. 2012). Constructivism integrates the learner within his observations in a cycle of creation and representation. Design Thinking is a constructivist learning design, because of its qualities in training specific

skills, which are predispositions for a constructive way of learning: motivation for exploration, openness for new ideas, creative thinking and other metacognitive competences (Noweski 2012).

The constructivist learning signifies that learners construct knowledge on their existing knowledge by themselves (Piaget 1970) and describes learning as an activity of making sense of individual experiences (Wheatley 1991). "Cognitive development and deep understanding" are at the center of the learning process (Fosnot and Perry 1996, p. 23). Cognitive and metacognitive studies contribute to constructivist perspective since it is accepted that learning is a process highly related to constructing knowledge, which is affected by the learners' prior knowledge (O'Dennell 2012). Learning is an active process that is related to an individual, social and continuing creation of meaning process (Piaget 1970). Constructivist learning is derived from a real context through interaction (Wilson 1997) and learning is an "interpretive, recursive and non-linear" process accomplished by active learners (Fosnot and Perry 1996). In interactive constructivism approach, learner constructs the knowledge by social interaction with other individuals, therefore learning construction accepted as social. The knowledge is built by reflections on social interactions (Henriques 1997). The fundamentals of the constructivist learning approach are; learner's past and existing knowledge is valued; pedagogy is shaped upon this; education is constructed actively by the learner with individual and social ways; reaching an understanding is an adaptation process (Olssen 1996).
Some defining characteristics of constructivist learning theory are (Banks 2001):

- Learning is an active process of constructing knowledge, based on one’s current cognitive structures, interacting with external inputs. Hence the learner will have a central, self-managing role.
- Knowledge is internal, based on the individual’s cognitive structures, and ways of relating to the world.
- There is an explicit notion of the level at which a learner is operating: whether conceived in terms of Piagetian levels, Bloom’s cognitive taxonomy, level of abstraction, or in other ways.
- The employment of learning for problem-solving and reasoning is an understandable concern.
- Metacognitive processes, including planning one's learning and reflection on it, are essential (Banks 2001).

Constructivist design thinking education has been applied by active project processes planned in the scope of design thinking mindset processes (Scheer et al. 2017) The instructors' mission is to lead process and pass the design thinking phases with the learners; emphasize different subjects in different phases upon the scope of the project; make learners reflect on their actions. Design thinking education adopts the constructivist approach to improve metacognitive skills. The design thinking mindset constructs on the learner's prior knowledge and thinking skills by self-initiative. Design Thinking can serve as the missing link between theoretical findings in pedagogy science and the actual practical realization in schools; leading to a transition from the transfer of knowledge to the development of individual potentials. It is considered that the learner can absorb the design thinking mindset easily by dealing the real-life problems and bringing solutions through the design thinking process in the constructivist learning approach. The instructor should get involved to the learning process to connect abstract knowledge with concrete applications and thereby and also learner should be able to convert and apply abstract and general principles (acquired through instruction) in meaningful and responsible actions in life (acquired through construction) (Scheer et al. 2012).

Design thinking learning has an interdisciplinary and constructivist learning approach (Plattner et al. 2009) and this kind of higher education also aims to develop boundary crossing skills (Spelt et al. 2009). “The capacity to integrate knowledge and modes of thinking in two or more disciplines or established areas of expertise to produce a cognitive advancement—such as explaining a phenomenon, solving a problem, or creating a product—in ways that would have been impossible or unlikely through single disciplinary means (Mansilla et al. 2000). Constructive alignment theory (Biggs and Tang 2011) which frames the comprehensive model for teaching and learning in higher education, is appropriate to clarify the higher education in the perspective of learning experience (Biggs and Moore 1993; Elisabeth et al. 2009). Constructive alignment model allows to evaluate teaching and learning activities alignment with desired learning outcome; thus, this model provides to improve comprehensive understanding in interdisciplinary learning approach (Spelt et al. 2009). This outcomes-based model is designed on the basis of constructivist learning approach (Biggs and Tang 2011) and focuses on the relation between intended learning outcome (ILOs), teaching/learning activities (TLAs) and assessment tasks (ATs) (Biggs and Moore 1993). Teaching and learning are considered as in four perspective as student, learning environment, learning process, and learning outcomes (Biggs and Moore 1993). The learning design explained in four steps;

1- Describe the intended learning outcome in the form of a verb (learning activity), its object (the content) and specify the context and a standard the students are to attain.

2- Create a learning environment using teaching/learning activities that address that verb and therefore are likely to bring about the intended outcome.

3- Use assessment tasks that also contain that verb, thus enabling you to judge with the help of rubrics if and how well students' performances meet the criteria.

4- Transform these judgments into standard grading criteria. (Biggs and Moore 1993).

Conceptual model of the learning outcomes of design thinking indicates the relation between skill-based outcomes, affective outcomes and cognitive outcomes (Taheri et al. 2016). Wrigley (2015) classifies the design thinking learnings with ''educational design ladder model'' depending on the research of design thinking courses in higher education (Wrigley 2015).

The design thinking education adopts constructivist learning approach which the learner constructs the knowledge on the existing knowledge by self initiative (Fosnot and Perry 1996). Although learner determines learning objectives in the constructivist design thinking learning, there should be defined learning goals and an understanding of the design thinking mindset to adopt a permanent thinking path for the learner. Constructive alignment approach (Biggs 1993) allows to frame the design thinking learning by defining ILO, TLA and ATs. The design thinking learning goals is to gain the design thinking mindset with the 21st century skills (Noweski et al. 2012) as critical thinking, collaborations, adaptability, communication, analytic thinking, curiosity and taking initiative (Wagner 2011). The learning planning is compiling the resources depends on the learning objectives; the learning planning includes actions and reflections depends on the Schön's reflective practitioner phenology (Schön 1982). The learner involves a project process as an interdisciplinary team with an instructor/facilitator which is planned by focusing on human values, showing not telling, creating clarity, getting experimental, being mindful, bias towards action and collaborating (Plattner et al. 2009). The learning assessment is based on the project process and project outcomes (Scheer et al. 2017).

Table 1: Design Thinking Learning Planning

Constructive Alignment *(Biggs and Moore 1993)*	***Constructivist Design Thinking Learning***
Intended Learning Outcome (ILOs)	Design Thinking Mindset Critical thinking, Collaborations, Adaptability, Communication, Analytic thinking, Curiosity and Initiative (Wagner 2011)
Teaching/Learning Activities (TLAs)	Reflection-on-Action / Reflection-in-Action (Schön1982)
	Fundamental Design Thinking Mindset (Plattner et al. 2009) 1) focus on human values; 2) showing not telling; 3) creating clarity from complexity; 4) getting experimental and experiential; 5) being mindful of processes; 6) bias towards action; 7) collaborating across boundaries
Assessment Tasks (ATs)	Design Thinking Project Assessments

Source: Author's conceptualization

Learning Object (LO)

Learning Object term has been used in similar ways like "knowledge objects" (Merrill 1999), "*instructional component (Merrill, 2000), "pedagogical documents*", than Learning Technology Standards Committee's "learning object" definition (LTSC 2002) has been accepted regarding its comprehensive statement (Wiley 2000). LOs are the artifacts that are shaped by learning objectives, learning goals, and learning methodology (Banks 2001). They are a collection of content items, practice items, and assessment items that are combined based on a single learning objective (Cisco System 2013). Institute Electronic and Electrical Engineers (IEEE) describes learning objects as any entity, digital or non-digital, that may be used for learning, education or training. A learning object is the smallest independent formative experience that contains an adequately aligned objective, a learning activity, and an assessment that truly measures the stated goal (Polsani 2003). Learning objects are described as "appropriately" small, fundamental, stand-alone, and reusable artifacts (Pearson 2016). LOs extend human capabilities as physical tools, an intelligent tool enhances performance on cognitive tasks. That's why learning objects are similar to training wheels, providing a steadying influence during those periods of disequilibrium brought on by new ideas

that may challenge established and comfortable habits (Wiggins and McTghe 2005). As well as traditional educations also using online platforms and it allows hybrid learning approaches (Griffith et al. 2003). Due to these improvements, teaching term has changed as learning; therefore, LO term accepted as a general term. LO subject has a pioneer position regarding developing learning technologies in the perspective of generativity, adaptability, and scalability (Hodgins 2002; Urdan and Weggen, 2000; Gibbons et al. 2000). In order to improve common work areas about developing instructional technologies, instructional technology standards have been created, especially on the focus of LO (Willey 2000). Reusability and adaptability properties of LO has increased the learning efficiency and competitiveness, hence, it allows to come existence diverse educational systems (Urdan and Weggen 2000, Willey 2000).

Learning Object Design

The design of LO, which is a fundamental part of an education, is getting significant priority that can affect the whole learning process(Kirschner 1996). Banks' (2001) Learning theory and LO approach frames the general properties in three steps; Sequencing and overall flow of learning; learning objectives and context; the learner's engagement, role in contextualization, and reflection subjects are determinant for the LO design (Banks 2001) which is similar in the learning planning (Biggs 2003). LOs are pieces of education that instructor conceives, define, design, develop, produce and deliver (Kirschner 1996). Moreover, also, LOs has to provide obligation of education system depending on the country where will LOs will be used; learner should understand the LO relations and value system behind them; learner should be informed why a particular focus or method has been chosen (Ginkel 2008).

Each education needs diverse sized LO depending on their granularity levels, therefore; Ritland et al. (2000) propose that different-sized LO usability in the learner-centered application as micro-sized, compound, macro level learning objects. *Micro-sized objects* include context-free contents and can be used for creating new materials by learners. *Compound objects* exist on a micro to macro level continuum from material with minimally added context. They could populate frameworks and student artifacts, stand alone as learning experiences, or offer just-in-time help or guidance. Frameworks represent macro level scaffolding. They are contextualized by the implementation of specific instructional approaches and can incorporate other learning objects and various kinds of links. The framework provides the context or structure for the learner and is defined as an object within the database (Ritland et al. 2000).

LOs are reusable, small learning units that aim to support teaching. The primary purpose of the objects prepared for learning is to be re-used by different users in different contexts and different aims. Ideally, these objects can produce unlimited contents by various combinations (Wagner 2002) Reusable LOs meet the needs of both instant learning (instructional base and skill-based courses) and non-class based learning experiences for future (Barrit and Alderman 2004). Learners can build their knowledge by interacting with LOs, instructors and other learners (Palincsar 1998). LOs interaction models can be framed based on learning and teaching activities that LOs should provide: activate prior knowledge; support conceptual change ; give expert models and guidance; give possibility to face the complexity of the content; give multiple representations; support collaboration that directs to thinking and explaining; visualization of thought; analogical reasoning; skill training (Ilomaki 2003).

Learning theories argue that learning occurs depending on the previous experience of the learner (Biggs and Moore 1993; Fosnot and Perry 1996). In this context, LOs can help the learner to think on the previous knowledge about learning context and realize knowledge borders of it (Ilomaki 2003). Therefore, LOs can include questions to trigger thinking and some cases that can contradict the previous experience of the learner. Misuse of concepts can cause ineffectiveness and lack of the learning process that's why LOs should support concept change (Ilomaki 2003). The learner can have difficulty to understand due to concept mistakes. That is why learners should consider their prejudices and understanding by the conceptual changing processes. In this process, the conceptual structure of the learner reconstructs to build new knowledge (Wilson 1997). LOs can be used to trigger the prior experience of the learner, gives the opportunity to express themselves and interact with content by using various combinations of LOs. Therefore, LOs can be planned as a tool that occurs misunderstanding by interacting with the learner and allow them to use different LOs in the same content (Ilomaki 2003). Learning environments usually simplify the real-life situations and present understandable models. However, this can cause the learner to lack linking and realizing within real life. For this reason, learning content, activities, and processes represent real-life situations. Therefore, LOs should include real-life problems and diverse solution paths (Ilomaki 2003). Social interaction makes a subject or content to understand easily. That is the reason why there should be prepared LOs to support social interactions like parallel or non-parallel research missions or group works (Palincsar 1998). Learners have difficulties to realize their learnings during the learning processes. Concept mapping, performance evaluations, process models and visualizations can support analogical reasoning processes and let them think on their knowledge. Also, the learner can evaluate themselves by comparing them with others, so it can be helpful to do individual works to be reachable (Ilomaki 2003). Traditional educational approaches cause learners not to transfer their learnings to different situations (Kılıç 2004). That is why there should be prepared LOs to allow the learner to move their knowledge to practice in various real-life cases (Ilomaki 2003). LOs of skill training educations should focus on one or two skills that learner can adjust the number and difficulty level by themselves and give feedback to individual performances (Ilomaki 2003)

Table 2: LO Design Drivers

Learning Theory and LO *(Banks 2001)*	***LO Sizes*** (Ritland et al. 2000)	***LO Properties*** (Ilomaki 2003).
Learning objectives and context; Sequencing and overall flow of learning; The learner's engagement,	Micro-sized LO Compound LO Frameworks LO	activate prior knowledge; support conceptual change ; give expert models and guidance; give possibility to face the complexity of the content; give multiple representations; support collaboration that directs to thinking and explaining; visualisation of thought; analogical reasoning; skill training

Source: Author's conceptualization

In this regard; LOs are the fundamental part of a learning process and have specific features depending on the learning approaches. LO are classified by their size as mic-sized, compound and framework LOs. LO design factors framed as learning objectives and context, sequencing and overall flow of learning and the learner engagement (Banks 2001). Although the LO properties depends on the LO design drivers, there are some common properties that can be named as a common properties as activating prior knowledge, supporting conceptual change, giving expert models and guidance, giving possibility to face the complexity of the content, giving multiple representations, supporting collaboration that directs to thinking and explaining, visualization of thought, analogical reasoning, skill training (Ilomaki 2003). Therefore; constructivist design thinking LO and LO design factors will be explored in the following section by these perspectives.

Findings: Design Thinking Learning Objects

LOs are the fundamental part of a learning process (Pearson 2016; Polsani 2003) and the core elements of learning planning. In order to define the design thinking LOs; constructivist design thinking courses are searched in literature. The research indicates five LO subjects as inputs, method cards, templates, schedules and project documentation materials.

Inputs (Kelley and Kelley 2013; Taheri and Meinel 2015) are component-based LOs, that learners can get the instructional knowledge, like expert talks, presentations, narrations, videos or readings as a scaffold for the mindset and then transfers the knowledge to practice by experiencing in the project process (Ilomaki 2003).

Method Cards (Brenner et al. 2016), are the method pools that includes design thinking methods used in the project process depends on the project needs.

Templates are the outlines for the actions in the projects that helps learner to follow the steps and focus on the project process and are assessment tools and visible for other learners that can compare themselves, find some usable ideas for own projects and create social interaction (Taheri and Meinel 2015; Lembcke 2016).

Schedules are the daily, weekly and semester based course guides, that helps learner to be aware of the project and learning process (Ilomaki 2003).

Project documentation materials (Menning et al. 2014), are the template base materials that helps learner to document the design thinking project and reflect on learnings. Documentation-supporter LOs are designed for each design thinking phases separately. These LOs can support the knowledge scaffold by including instructional knowledge about the stages. If the LO helps the learner to outline project outcomes of the stages, the learner can be motivated to focus on the process (Menning et al. 2014).

Design Thinking Learning Objects' Granularity

Ritland et al. (2000) classified the LO to three layers of granularity depending on their sizes, as micro-sized LO, compound LO and framework LO. In that context, constructivist design thinking LO can be classified.

Micro-sized LO includes context-free contents and can be used for creating new materials by learners (Ritland et al. 2000). The templates and method cards which are the learner-generated LOs are used in the project processes as a guide includes a context-free of content. These LOs include graphics, video or sound clips, definitions, de-contextualized explanations.

Compound LO exists on a micro to macro level continuum from material with minimally added context (Ritland et al. 2000). They could populate frameworks and student artefacts, stand alone as learning experiences, or offer just-in-time help or guidance (Barritt and Alderman 2004). The project documentation materials complete training activities which can both include content about the design thinking process and allow the learner to create its content.

Frameworks LO represents macro level scaffolding. They are contextualized by the implementation of specific instructional approaches and can incorporate other learning objects and various kinds of links. The framework provides the context or structure for the learner and is defined as an object within the database. (Ritland et al. 2000) Design thinking inputs include narrations and presentations that used for instructional knowledge about design thinking process and mindset. These LOs prepare the learner to action, synchronize and give the transferable knowledge. Also learning schedules can be accepted as LOs because learners can position themselves in the process.

Table 3: ***Constructivist Design Thinking Learning Objects Granularity Layers***

LO Granularity Layers (Ritland et al. 2000)	***Constructivist Design Thinking Learning Objects***
Micro-size LO	Templates, Method Cards, Schedule
Compound LO	Project Documentation Material
Framework LO	Inputs

Source: Author's conceptualization

Design Thinking Learning Theory and Learning Object Relationship

Learning appears by gathering LOs at the LO perspective (Banks 2001). Therefore, learning approach perspective determines how LOs are planned (Baruque and Melo 2003). Different learning approaches need different strategies (Banks 2001). The LO approach has to be considered from the standpoint of learning approaches. Learning approaches include applicable principles with the LO model. Therefore, design thinking LO has the characteristics constructivist design thinking learning process. The constructivist approach focuses on learning rather than teaching (Gallini 2001). This approach can be described as a knowledge construction process depending on the learner's individual experiences, cognitive structures, and beliefs (Jonassen 1991). Learning objectives, sequencing and overall flow of learning, the learner's engagement models determine LO design factors (Banks 2001). Hence constructivist design thinking

education will be considered to frame the LO design factors and make a connection with the research question of the article.

Learning principles are very close to the learning objectives, that emphasize certain learning activities, and these activities support, especially, specific goals. For this reason, applying learning principles in designing LOs means that the learning goals are defined first and then the appropriate policies will be used (Ilomaki 2003). Learning goals of design thinking education are to gain the design thinking mindset which is a creative problem-solving process. Design thinking mindset characteristics based on critical thinking, collaborations, adaptability, communication, analytical thinking, curiosity and initiative (Wagner 2011). Learning objectives can be accepted as guidance for LO usage and planning (Banks 2001). LO usage may not be enough to construct the knowledge, LOs are the supporter of the process. Learning can be built by the interaction between learner, instructor, and LOs (Karaman et al. 2007). However, learning objectives are determined by the learner in the design thinking education with the constructivist approach (Scheer et al. 2017). The learning planning in design thinking education is based on the experiencing of design thinking paths (Plattner et al. 2009). Learner constructs the design thinking mindset by "hands-on" project process that begins with problem definition end ends with solution creation (Oxman 1999). DT learning journey to gain a mindset in the framework of problem definition and creative problem solving; includes repetitive actions and reflections on actions (Kelley and Kelley 2013).

Constructivist LO designer should focus on the actual building of learning objectives and thinking on learning (Banks 2001). The focus is on the learners' demand on education and appropriation to the existing prior knowledge of learner. Then, the center moves to the structural change from the previous experience. LO should motivate the learner to get involved in action rather than indicating what to learn or what should have learned (Banks 2001). Luka (2014) proposes that designing LOs, which improves learner's problem-solving skills and usable both by individual and group, has a significant potential for learning (Luka 2014). In this regard, the LOs are the supporters for the design thinking learning process as a fundamental unit.

Teaching and learning activities (TLA) are the process which the learning occurs by the learner (Biggs and Moore 1993) and TLA planning is a process plan to reach learning objectives (Biggs and Tang 2011). In the learning journey of design thinking education, the learner involves to a project process which consists of problem definition in the scope of the project, creates a solution to the defined problems, choosing the most

feasible idea for the project scope and delivering the outcome (Efeoglu 2012). The learner should pass all design thinking phases during their project process (Plattner et al. 2009). The active practice continues with interdisciplinary teams in the company with one or multi instructors. This dynamic project process becomes learning by reflection on actions (Schön 1982; Wilson 1997). The mindset is constructed by the learner reflections, which learning actions that create awareness of the learner. The learner makes the considerations with the help of LO and instructor. LOs should provide the answers to the learner about; the learning expectations from LO; ability to use the LO (does learner's prior knowledge should be enough to use that LO; what are the supporter LOs or new understandings; appropriation with the learning journey (Banks 2001). A typical LO projects the answers and presents some supporters to the learner to inform about learning needs and prerequisites for LO usage; questions the abilities before and the learnings afterwards (Wilson 1997).

Laurillard (1993) has suggested some steps to create constructivist learning process: The learner should select learning goals and subgoals; Learning activity starts, and interaction completes by the learner; LO should give feedback to support thinking on learning; Learner should write their reflections. Moreover, learners should socially interact with other learners to compare learning outcomes to realise their learnings and reflections (Laurillard et al. 2000). Small units allow the learner to think on learning and construct their knowledge rather than bigger units (Banks 2001). Therefore, small and separated LOs are more appropriate for constructivist learning approach predictions. LO can be used as a tool in the problem-solving process. For instance; a LO can be an empty template that includes specific steps for the procedure. Learners can use that template for guidance. This template provides a structure for the learning process (Ilomaki 2003)

Design thinking learners should interact with other learners, instructors, and LOs during their learning process (Palincsar 1998). The interdisciplinary working teams allow learners to improve their communication skills and create a collaborative culture; the learners can bring creative solutions to everyday life, and work-related problems (Luka 2014). Design thinking has been defined as a team-based transformation of constructivist learning approach into learning method, which helps to deal with complex issues by sustaining in-depth learning processes on problem perception and diverse solution paths (Kroper 2010). The LO effectiveness depends on the application of the planning by time and environment (Banks 2001). Learning planning process can be defined as a process design by using LOs in different size and properties. An active learning plan is a balanced composition of instruction and construction (Scheer et al. 2012).

Dewey (1938) would say "construction through instruction" (Dewey 1938; Scheer et al. 2012). Component-based objects can be used to construct a learning scaffold in the learning process (Ilomaki 2003). The learner should be supported during their learning journey, and the learning plan should predict the supporting steps. These steps can be small units. The learning plan contains the process of gaining the learning objective. The learner has some missions in that process; such as defining the learning goals clear and sharp; creating the learning planning; combining the resources and LOs appropriate for the plan (Ginkel 2008).

The learning is completed when the plan works (Willey 2001). Both the plan and the application can include a unique environment. Learning or LOs' effectiveness depends on the sequencing and application environment (Banks 2001). Learning engagement depends on learning architecture (Griffith 2003). Barrit and Alderman (2004) discussed that LO usage depends on the learning architecture and frames the relation for a directive, receptive, guided discovery, exploratory environments. Learning is presented in a planned linear order in a receptive environment. The directive environment allows learning to be applied in order. Learners can make a journey in the learning environment in guided discovery. The learner makes their learning journey by individual initiative in an exploratory environment as in constructivist approach. The primary motivation of learner is to realize their knowledge and skill needs. The learning environment can be considered as a LO pool that can help courage learners to find their own needs to construct knowledge in an exploratory environment. The exploratory learning environment is adopted by design thinking education due to the LO approach and usage styles. The access paths to resources should be defined, but learners should be informed about the resources. (McNaught et al. 2003). The learner can make research and journey about content (Coombs 1998). The learner motivation on finding personal learning necessity is the most critical factor for getting knowledge and improving skills for the learner. Design thinking education as a learner-centered active learning process approach proposes that the design thinking project subject should be chosen depending on the learners existing skills and interests. The issues should be from everyday life problems and with an appropriate difficulty level to motivate the learner. Therefore, diverse LO pools have to be prepared which can help learner in learning journey and a motivative learning environment should be created to reach the necessary knowledge and skills.

LO can support activation base studies (Chapuis 2003; Karaman et al. 2004). Active learning includes the real problems that learners can practice and can get feedback from instructors and others. For this

environment, learner-centered LO should be designed rather than component-based LO that the skills of the learners should be considered to motivate the learners (McGee 2006). The learner uses LOs in the design thinking learning process that LO shall inform the user about the usage conditions, aims, design thinking phases, and user abilities (Wilson 1997).

Table 4: *Constructivist Design Thinking Learning Theory and LO Relationship*

Learning theory and LO *(Banks 2001)*	***Constructivist Design Thinking Learning***
Learning objectives and context;	-Design Thinking Mindset -Critical thinking, Collaborations, Adaptability, -Communication, Analytic thinking, Curiosity and Initiative (Wagner 2010)
Sequencing and overall flow of learning;	**Constructivist Learning Approach (Laurillard 2000)** -Learning goals selected by learner -Learner activity depends on learner initiative -Support reflection -Social interaction
The learner's engagement,	Exploratory Learning Environment (Barrit and Alderman 2004)

Source: Author's conceptualization

Design thinking LO design factors have been framed in the perspective of learning experience as learning objectives, learning flow and learner engagement relations. The goal of the learning is to gain the design thinking mindset by gaining skills as critical thinking, collaborations, adaptability, communication, analytic thinking, curiosity and taking initiative (Wagner 2011). The constructivist learning approach frames how the learner can gain the design thinking mindset in the exploratory learning environment (Karaman et al. 2007). Therefore; design thinking LO properties are inferred depends on the literature review in the following section.

Conclusion: Design Thinking Learning Object Properties

The characteristics of constructivist Design Thinking LOs are framed in the perspective of learning objective, learning activities and learner engagement. LOs are reusable, reachable, customizable, improvable in the learning theory and LO relationship (Banks 2001). Regarding literature research, the general properties of constructivist design thinking LOs regarding LO approach can be framed as;

- LOs should question and activate learner's existing knowledge (Fosnot and Perry 1996). Design thinking LOs make learners think about their existing problem-solving abilities, consider paths and help the learner to realize the borders by reflecting on the learnings.
- LOs have to support a conceptual change in learners by reviewing existing prejudices, understandings and emphasizing misuses (Ilomaki 2003). Therefore, LOs should provide a base for reconstructing a new concept by supporting social interactions and aiming to gain different aspects.
- Learning goals are seen as coming from the learner, rather than from the resource in the constructivist approach (Olssen 1996). The learning goals are linked with the published resources which are indicative guidelines on how the LOs can be used.
- The subject of the design thinking project should reflect the real-life situations (Plattner, Meinel and Weinberg 2009), and learner should experience them directly to transfer knowledge (O'Dennel 2012). Therefore; LO content should be used with different problems in real life. Each project has to be solved with different tools, so objects have to be customizable according to the user needs (Boskic 2003). LOs are placed as a guide for transferring the knowledge; therefore, LOs should have a highly interactive level and be re-usable in different context and problems.
- LOs are open for common intervention to improve social interaction (Palincsar 1998). Design thinking LOs should make learner to think on personal learning and evaluate themselves by comparing with others since design thinking mindset learning is based on reflections.
- LO should inform learners about its usage competence and scope to let the learner define a goal for skill improvement (Noweski et al. 2012). A crucial requirement for learning objects is that their metadata should enable the exact learning object to be located.
- The design thinking process is an unpredictable and dynamic process (Buchanan 1992), so LO has to be reachable (Coombs 1998) and have a supporter role in enabling a goal to be reached through (for example) the interaction between learner, teacher, peers, and learning object.
- Each LO should be able to solve current and future projects (Boskic 2003), so it has to be improvable by the user feedbacks and researches.
- The LO should be encouraging, rather than simply stating what to learn or should have learned (Wilson 1997).

The evaluations in this paper, regarding the LO features are based on the research of relevant literature on constructivist learning approach adopted by Design Thinking Education.

Future Studies

Main effort of the literature research, that is used to show the relationship between constructivist design thinking learning and LOs, is to introduce design thinking, its pedagogic approach and LO approach. According to literature research, constructivist design thinking LOs have been defined and classified depending on their size, design factors and furthermore general LO features has been framed. The LO is a fundamental part of learning; it carries the characteristics of learning goals; therefore, by clarifying the design thinking LO, it is possible to identify design thinking learning. This article, by following a literature research and drawing a framework regarding various considerations and discussions in the relevant field, aims to contribute to the efforts on understanding the education industry and design thinking research.

In the scope of the article, it can be interpreted that the relationship between LO design and design thinking learning objective alignment has potential for research. The contribution of LO design to the constructivist design thinking learning, can be an empirical learning design research statement. Besides, the assessment of constructivist design thinking learning objective alignment is a discussion subject that indicates the research potential to contribute to design pedagogy. Moreover, the evaluation of LO, which used in constructivist learning approach, can be a research subject regarding pedagogic literature. Finally, a learner experience and learner interaction design research on design thinking LOs can provide to evaluate the process from the learner perspective and improve learning efficiency by LO usage. Hopefully, it will open up a new discussion on alternative methods in this field and inspire LO designers, learning planners and researchers to explore the future possibilities.

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