ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

APTITUDES AND ATTITUDES
HUMAN-CENTRED PEDAGOGIES IN FOUNDATION DESIGN STUDIO

Ph.D. THESIS

Desantila HYSA

Department of Architecture

Architectural Design Program

SEPTEMBER 2021

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Thesis Advisor: Prof. Dr. Mine ÖZKAR

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

YETENEKLER VE TUTUMLAR: TEMEL TASARIM STÜDYOSUNDA İNSAN-MERKEZLİ EĞİTİM

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Desantila HYSA, a Ph.D. student of ITU Graduate School student ID 502132004, successfully defended the thesis entitled "APTITUDES AND ATTITUDES: HUMAN-CENTRED PEDAGOGIES IN FOUNDATION DESIGN STUDIOS", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To everyone who made this possible,

FOREWORD

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September 2021

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SUMMARY

Attitudes (dispositions) complement knowledge and skills in a competency-centered curriculum of higher education. They refer to the affective learning dimension, and it is challenging to address and assess them. But they are the crux – when, how, and why to apply the knowledge and skills. In architectural design curricula, attitudes are especially relevant to ensure the training of responsible designers. Although humanistic and environmental issues are increasingly in the spotlight, attitudes endorsed in most schools' studio cultures tend towards the black box of individual creativity more than collaborative and participatory processes. As computational methods that expound the reasoning processes of design become ever more popular, new opportunities arise for open and liable design cultures. Yet, connecting these methods to a broader competency in design is still in progress.

This thesis establishes the transdisciplinary context and a conceptual framework for computational methods to implement and assess accountability as an attitude in design education. It involves the development of the designerly character, the training of judgment in performing aptitude. It further shows that computation in early design education supports the cultivation of desired attitudes such as knowledge sharing and consequent accountability. Computational formalisms, such as shape rules, are devices of visual computing that help designers externalize and share design ideas for collective reflection. While documenting thought processes, they support beginning designers in developing a sense of accountability for their design thinking as necessary for reflecting critically.

As knowledge and skills are in constant change, attitudes and values are still the core that guides action in design. The overview presented here on the topic points to an ever-growing need to address attitude in architectural design education. The sharing in a collaborative learning environment result in greater opportunities for reflection, and, consequently, learning with accountability. This study highlights the following ethical dimensions of design: a. the externalization of one's design reasoning brings transparency to the process, b. transparency enables self and others to trace one's reasoning and actions, c. sharing one's knowledge and reasoning initiates reflections for further actions. The "externalizing, sharing, and reflecting" motivates accountable actions in the design environment.

Furthermore, the study refers to the use of analog computational tools which enable reflection in an educational setting. Five points of impact are identified: a. visual computation has the potential to create original languages of design or to analyze existing languages, still allowing for creative expression, b. the explicitness of visual design computation enables the designer to externalize the design process to a certain extent, c. externalization when followed by sharing with the members of a community, gives opportunity to reflect on past reasoning, internalizing, and regenerating other concepts, externalizing, because of the materialized sharing, d. reflecting on one's

reasoning, or thinking about thinking points to the inherent metacognitive aspect of the reflective practice, e. metacognition is a condition for attitudes to be learned and changed over time as sequential reflection contributes to developing dispositions of how to act in future situations.

The motivation behind this research is to show the methodological impact of computational design thinking on supporting the learning of attitudes while viewing design as a social act of creation. Allowing more computational methods in the design studio pedagogy holds potential for enhancing the grounds for reflecting, partaking, and answerability. John Dewey wrote on cultivating reflective thinking, through hands-on art, as a character in the learner. In the design literature that Donald Schön spearheaded, reflection is a mode of inquiry that situates the learner in different experiences, enabling a deeper awareness while interacting socially.

Reflective practice demands intellectual attitudes which are intrinsically moral. At the same time, there is an ever-growing need to cultivate values and attitudes that acknowledge the computational and digital turn of design in higher education. In this research, I propose and test analog computational tools in a foundation design studio to understand whether making visible the divergence and convergence of thought provides a ground for reflecting, partaking, and answerability. Embracing design as computation and computation as design, the externalization of the process serves a societal purpose. It evokes accountability and sharing. The openness of visual computing in basic design serves to document thinking processes, but it also helps beginning designers develop an understanding of what design thinking entails for communication and collaboration. Thus, computational methods may allow for open design education in support of democratic studio environments, where "openness" is read at different layers: an open design process, being open to peer review, open to collaboration, open to sharing, and open to embracing the views of others. Such attitudes are instrumental in design processes for liable conduct towards colleagues, users, and the environment.

This research presents the outcomes of a longitudinal study performed in a beginning design studio. The linguistic analysis of students' reflections shows that a rule-based approach to design incites accountability attitudes among learners even in a brief period. This study reveals that computation in early design education fosters the desired attitudes such as knowledge sharing and consequent accountability.

The basic design studio is an inclusive environment where active individuals engage with tools and opportunities to articulate their thought and production processes. Alongside a technical aptitude, the student reflects and develops personal values during the experience. Learning design is about training judgment. How effort and exertion train judgment is both personal and collective, making the studio the pragmatic and at the same time creative design learning environment it is. These reflective learning environments implant attitudes. Computation is not a burden but the means to reflect, share, compare, and alter in the transcending and empowering learning experience of the basic design studio.

YETENEKLER VE TUTUMLAR: TEMEL TASARIM STÜDYOSUNDA, İNSAN-MERKEZLİ EĞİTİM

ÖZET

Yükseköğretimde, öğrenim çıktıları olarak bilgi ve becerileri tamamlayan tutumlar, doğrudan değerlendirilemeyen yeterlilikler olarak genellikle geri planda kalır. Mimarlık eğitiminde hümanist, sürdürülebilir ve çevreci yaklaşımlar küresel ve yerel gündemlere uygun olarak artarken okulların stüdyo kültürlerinde benimsenen tutumlarda, işbirlikçi ve katılımcı süreçlerden çok bireysel yaratıcı süreçler ön plana çıkabilmektedir. Hesaplamalı tasarım yöntemleri ise tasarımın muhakeme sürecini açık ederek paylaşımcı tutumları beslerken, açık ve sorumluluk bilinci güden tasarım kültürleri oluşturmak için yeni fırsatlar sunmaktadır. Bu çalışma, hesap verebilir olmayı bir tutum olarak tasarım eğitiminde uygulamak ve değerlendirmek için kullanılan hesaplamalı tasarım yöntemlerine disiplinler arası bir literatürle bağlam ve kuramsal bir çerçeve sunmaktadır.

Eğitimdeki bilgi ve becerilerin bir tamamlayıcısı olarak tutumlar, kişisel davranışların yanı sıra kişinin düşünce kalıplarını yönlendiren eğilimler ve alışkanlıklardır. Literatürde 70'lerden bu yana duyuşsal (*affective*) öğrenme çıktıları kategorisine yönelik tutumlar var olsa da epistemolojik çerçeveleri geniş ve çeşitlidir. Eğitimde duyuşsal sonuçlar genellikle empati, etik davranış veya başkalarına saygı gibi değerlerin değişimini veya gelişmesini içerir. Tutumlar, ait olduğu topluluğun değerlerini ifade etmek için bir temel sağlarken, pedagojik bir yaklaşım, tutumları etik değerleri geliştirme aracı olarak ideal kılar. Tasarım eğitimi bağlamında, tutumların oluşumu kısmen tasarım pratiğinin etiği ve tasarımın bilgisinin paylaşılması ve bunun sonucunda tasarımdaki hesap verebilirlik gibi konularla ilgilidir. Tutumların genellikle müfredatta örtük olduğu varsayılmaktadır, ancak eğitim araştırmalarında önemli bir bilgi ve beceri tamamlayıcısı olarak kalmaktadır. Mimarlık eğitiminde bu çok farklı değil. Araçların dijital dönüşünü ve tasarımdaki iletişim modlarını benimsemeye çalışan mimarlık programları, sürekli olarak yeni ilgili becerilerin öğrenilmesini içermektedir. Bilgi ve etkileşimli teknolojileri öğrenirken, teknik ağırlığa yapılan vurgu, aynı anda ne tür tutumların teşvik edildiğini göz ardı eder. Tasarım ve yapma araçlarının ve yöntemlerinin hızla geliştiği günümüzde, en çok disiplin becerilerine dayalı bir eğitim sorgulanmaya açıktır. Bilgi paylaşımı ve işbirliğine dayalı tasarım pratiğindeki hesap verebilirlik konusundaki sürekli büyüyen ihtiyaç, bilgi araçlarındaki ilerlemeye ve zamanımızın ilgili teknik becerilerine paraleldir. Dijital teknolojinin, tasarım ekibinin çeşitli üyeleri arasındaki diyaloğa yardımcı olarak tasarım süreçlerinin sosyal yönlerini arttırma potansiyeli olduğu hali hazırda düşünülüyordu. Bu tezin arkasındaki motivasyon ise, mimarlık eğitiminde, tasarımı sosyal bir yaratma eylemi kabul eden yaklaşım üzerinde hesaplamanın metodolojik etkisini gösteren bir kuramsal çerçeve ve vaka oluşturmaktır. Hesap verebilirlik ve paylaşım, şeffaf süreçler ve tasarımın sosyal edimi ile ilgilidir. Referans çerçevesi uygulamaya uzanır, ancak odak noktası bu tür bir uygulamadan önce gelen öğrenmeye odaklanır.

Etik, tasarım pratiği, tasarım ürünü ve kullanılan teknolojiyi kapsayan temel bir konudur. Tasarımdaki geleneksel etik söylem ahlaki yargılarda bulunma eğilimindedir. Buna karşılık, bazıları etiğin bir tasarım biçimi olduğunu ve tasarımcının etik sorunlara yaratıcı bir şekilde yanıt veren ahlaki bir ajan olduğunu iddia eder. Alternatif olarak, tasarımın bir etik biçimi olduğunu düşünülebilir. Tasarım pratiği, etik davranış biçimlerini ve bu davranışın başkalarına ve genel olarak topluma karşı muhasebesini içerir.

Mimarlık eğitiminde mesleki uygulamalar için gerekli etik tutumları geliştirme çabaları sınırlıdır. Etik eğitimi için hedefler açıkça tanımlanmıştır ve çoğu yüksek öğrenim kurumu, etiği "müfredat genelinde" ele almaktadır. Bazıları, değerlerin farkındalığı ve yansıtıcı becerilerin geliştirilmesine katkı sağlayarak etiği öğrenmeye dahil eder. Genellikle bağımsız kurslarda ya da vaka temelli öğretimde etik ilkeleri, etik pedagojileri çok fazla şey sunar, ancak tasarım stüdyosunda gerçekleştirilen eylem türlerini özel olarak ele almaz. Tasarım alanına özgü, mesleğin gelecekteki sorumlu davranışı için tasarım eğitimindeki çevresel tutumları vurgulayan araştırma vardır. Buna karşılık, etik akıl yürütme öğrenme süreçlerinin karar alma ile sınırlı olmasına rağmen, tasarım öğrencilerinin bu tür akıl yürütmeyi daha büyük eylem yapılarına yerleştirme konusunda bir farkındalık geliştirmeleri gerekmektedir. Bu farkındalık, nasıl davranılacağı, yani tutumlar hakkındaki varsayımlara yol açar. Kolektif amaçlar için tasarım sürecinin değerine odaklanan çalışmaların yanı sıra, bu araştırma bir tasarımcının tasarım sürecinde meslektaşlarına yönelik davranışlarını bildiren değerlere dönüşür. Hesap verebilirlik ve şeffaflık değerleri, bir kişi veya kuruluşun olumlu özellikleridir. Bu nitelikler sadece etik bir duruş sergilemekle kalmaz, aynı zamanda tasarım sürecinde de etkilidir. Hesap verebilirlik ve şeffaflığın değerleri, muhakemenin açık yapılmasını gerektirir. Tasarım eğitiminde, yansıtıcı uygulama, mesleki etik olarak sürdürülebilir tasarıma karşı sorumluluk için temel kabul edilir. Tasarımla ilgili literatürlerin çoğu, onu son kullanıcılara karşı ahlaki sorumluluklara bağlar. Mesleki tutumlar lisans programlarında olduğu gibi "mesleki alanda daha derin katılım" ile de kazanılır. Bunlar tasarımcı olarak sorumluluk ile karakterize edilir. Tasarım sürecinin sosyal yönü ve yansımanın buna nasıl katkıda bulunduğu hakkında çok az şey var. Bunun bir istisnası, yönetim alanındaki tasarım tutumlarına odaklanan son tasarım araştırma literatürüdür. Bu, tasarımcı rolünü örgütsel alanlara yansıtıcı düşünürler olarak tanıtmasını ve tasarımın insani yönlerine olan tutumunu genişletmesini izler. Yansıtmalı bir süreç olarak tasarımın bu perspektifleri, yansımayı bir sorgulama biçimi olarak gören ve içsel olarak etik ve ahlaki olan entelektüel tutumlar talep eden Dewey'in felsefi geleneğine dayanır. Bu nedenle, yansıtıcı düşünme tutumları teşvik etmek için bir yöntemdir ve aynı zamanda yansımaların gerçekleşmesi için tutumlar gereklidir.

Alternatif olarak, bir tasarım dili görsel hesaplama bağlamında şekil kuralları ile tanımlanabilir. Hesaplama tasarımının teknolojiye saygının aksine, yapım bilgisi ve bir donanım kullanma becerisiyle sınırlı olarak, işlemin ürün üzerindeki rolünü kabul eden daha geniş bir hesaplama anlayışı vardır. Hesaplamalı tasarımın soyut bilgisi, öğrenciyi tasarım düşüncesinin akranlara ve genel olarak topluma karşı sosyal sorumluluklarından uzaklaştırıyor gibi görünmektedir. Farklı olarak, hesaplama sürecinin, tasarımcının, sosyal açıdan bilinçli bir tasarımcının eğitiminde arzu edilen tutumları aşılayarak sosyal ilgi alanına hizmet eden sürecin dışsallaştırılmasını sağladığını düşünüyoruz. Artan sayıda birinci sınıf mimari tasarım stüdyosu hem dijital araçların kullanımı hem de (ideal olarak görsel) kurallarla dışsallaştırma süreçlerinin hesaplamalı tasarım becerilerini içeriyor. Görsel tasarım hesaplamasının

açıklığı, tasarımcının tasarım sürecini bir dereceye kadar dışsallaştırmasını sağlar. Şekil veya görsel kurallar, yeni tasarım dilleri yaratma veya var olanları analiz etme potansiyeline sahiptir. Stüdyo yöntemlerinde kabul edilenler, tasarım sürecindeki kararların görsel temsilidir ve işbirliği aracı olarak hizmet ederler. Tasarıma yönelik kurala dayalı yaklaşımlar, öğrencilerin işbirlikçi uygulamalardaki eylemlerin dış yorumlanması için aracı olduklarından "bireysel tasarımdan tasarım dillerine geçmelerine" yardımcı olur. Genel olarak tasarım eğitimine kurala dayalı yaklaşımların bütünleştirilmesinde değerli öneriler vardır, ancak bu pedagojiklerin desteklediği tutumlar konusunda çok fazla araştırma yapılmamıştır.

Yapıcı görüş, bireylerin yapılarının dış ve ortak olduğunu iddia eder. Bu, bir sürecin veya ürünün dışsallaştırılmasının bir topluluğun üyeleri ile paylaşılmasını gerektirir, böylece ne yapıldığı, içselleştirme ve yeni bir fikrin yeniden ortaya çıkması, dışsallaştırma, meydana gelen paylaşım nedeniyle yeniden düşünülmesine izin verilir. Tasarım stüdyosu, tasarımı parçalanabilir bir süreç olarak görme yeteneğini temsil eden işbirlikli öğrenme ile karakterize edilir. Birçok kişinin öğrenmenin farklı aşamalarında paylaşmasına, müdahale etmesine ve yansıtmasına olanak tanır. Bu görüşe göre, yansıma sürecine özgü bir meta-bilişsel boyutun olduğunu kabul ediyoruz. Öğrencinin kendisi ve diğer akranların bildiği ve öğrendiği hakkında bir farkındalık geliştirmesine yardımcı olur. Bu nedenle, yansımanın amacı, tasarım eğitimindeki tutumları teşvik ederek problem çözme veya önceki eylemleri hatırlamanın ötesine geçer.

Bilgi ve beceriler bir akış içinde olduğundan, tutumlar ve değerler tasarımdaki aksiyonu yönlendiren temel unsur olarak kalır. Burada konuyla ilgili genel bakış, giderek artan ve mimari tasarım eğitimindeki tutumları geliştirme ve değerlendirme ihtiyacına işaret ediyor. Tasarımı tasarım olarak hesaplama ve hesaplama olarak benimseyen sürecin dışsallaştırılması, tasarımın sosyal yönlerine hizmet ediyor. Bir tasarım sürecinde muhakeme ile ilgili hesap verebilirlik ve paylaşım sağlar. İşbirlikçi bir öğrenme ortamında paylaşmak, yansıtma ve dolayısıyla hesap verebilirlik ile öğrenme için daha büyük fırsatlarla sonuçlanır. Çalışma, tasarımın aşağıdaki etik boyutlarını vurgulamaktadır: a. tasarım mantığının dışsallaştırılması, sürece bazı şeffaflıklar getirir, b. şeffaflık, kendisinin ve başkalarının birinin mantığını ve eylemlerini izlemesini sağlar, c. birinin bilgisini ve akıl yürütmesini paylaşmak, daha sonraki eylemler için yansımaları başlatır. "Dışsallaştırma, paylaşma ve yansıtma" tasarım ortamındaki hesap verebilir eylemleri motive eder. Ayrıca, eğitim ortamında yansıtma sağlayan analog hesaplama araçlarının kullanımına atıfta bulunuyoruz: a. görsel hesaplama, özgün tasarım dilleri yaratma veya mevcut dilleri analiz etme potansiyeline sahiptir, yine de yaratıcı ifadeye izin verir, b. görsel tasarım hesaplamasının açıklığı, tasarımcının tasarım sürecini bir dereceye kadar dışsallaştırmasını sağlar, c. Bir topluluğun üyeleri ile paylaşılarak takip edildiğinde dışsallaştırma, yapılan paylaşımın yeniden gözden geçirilmesine, içselleştirmeye ve yeni bir fikrin yeniden ortaya çıkmasına, meydana gelen paylaşım nedeniyle dışsallaşmaya izin verir, d. birinin akıl yürütmesini veya düşünmeyi düşünmesini yansıtmak, yansıtıcı uygulamanın kendine özgü metabilişsel yönüne işaret eder, e. üst biliş, belli bir zaman diliminde öğrenilmesi ve değiştirilmesinin tutumu için bir anahtar koşuldur, çünkü sıralı yansıma, başka durumlarda nasıl davranacağına dair eğilimler geliştirmeye katkıda bulunur.

Bu araştırmanın arkasındaki motivasyon, hesaplamalı tasarım düşüncesinin pozitif değerleri öğrenmeyi desteklerken metodolojik etkisini ortaya koyarken, tasarımı bir toplumsal yaratma eylemi olarak görmektir. Tasarım stüdyosu pedagojisinde yukarıda

anlatıldığı gibi daha fazla hesaplama yöntemine izin vermek, yansıtma, katılım ve yanıt verilebilme gerekçelerini geliştirme potansiyeline sahiptir. Hesaplamalı formaliteler, öğrencinin zihinsel yapıları olarak, tasarımdaki (görsel) mantığı temsil eder. Bu şekilde hesaplama, tasarım stüdyosu ortamlarında, özellikle de ilk yıllarda, öğrenme deneyimini aşarak ve güçlendirici bir şekilde paylaşmanın, karşılaştırmanın, yansıtmanın ve değiştirmenin bir aracı haline gelir. Görsel hesaplamanın açıklığı düşünce süreçlerini belgelemeye hizmet eder, ancak aynı zamanda tasarımcılara tasarım düşüncesinin iletişim ve işbirliği için ne anlama geldiğinin anlaşılması için yardımcı olur. Dolayısıyla, hesaplama yöntemleri "açıklığın" farklı katmanlarda okunduğu demokratik stüdyo ortamlarını destekleyerek açık tasarım eğitimine olanak tanır: açık tasarım süreci, akran incelemelerine açık, işbirliğine açık, paylaşmaya açık ve başkalarını kucaklamaya açık 'sayısı. Bu tür tavırlar sadece tasarım sürecinde etkili değildir, aynı zamanda bir acemi tasarımcının tasarım sürecinde meslektaşlarına yönelik davranışlarını da bildirirler. Bu araştırma, bir başlangıç tasarım stüdyosunda yürütülen uzunlamasına bir tasarım çalışmasının sonuçlarını bildirmektedir. Öğrencilerin yansımalarının dilsel analizi, tasarıma yönelik kurala dayalı bir yaklaşımın, kısa bir süre içinde bile öğrenciler arasında hesap verebilirlik tutumlarını kışkırttığını göstermektedir. Bu çalışma, erken tasarım eğitiminde hesaplamanın, bilgi paylaşımı ve sonuçta hesap verebilirlik gibi arzu edilen tutumların aşılmasında destekleyici olduğunu göstermektedir.

1. INTRODUCTION – ATTITUDES, FOR DESIGNING, WITH COMPUTING

Attitudes (dispositions) complement knowledge and skills but are often overlooked as assessable competencies in higher education. In architectural design curricula, attitudes are especially relevant to ensure the training of responsible designers. Although humanistic and environmental issues are increasingly in the spotlight, attitudes endorsed in most schools' studio cultures tend towards the black box of individual creativity more than collaborative and participatory processes. As computational methods that expound the reasoning processes of design are ever more popular, new opportunities arise for open and liable design cultures. Nevertheless, connecting these methods to a broader competency in design is still in progress. This study establishes the transdisciplinary context and a conceptual framework for computational methods to implement and assess accountability as an attitude in design education.

This dissertation hypothesizes that computation in early design education supports instilling reflective attitudes by encouraging knowledge sharing with consequent accountability among learners. What is meant by computation here is an extended way of reasoning, having no predefined or inherent structure, just like in design. Computation, in this sense, is non-hierarchical and allows for emergent ideas while reflecting. The formal descriptions are not rigid but vary depending on seeing and thinking. This broader conception of computation supports variability and multiplicity in design thinking. Computational formalisms represent visual reasoning, work with shapes, and allow for dialogues with oneself and others. The focus is not on shapes but their formal descriptions, giving insight into how shapes relate in different design orders and transform in space. Visual rules capture and decontextualize design actions in a process, making them accessible and practical tools for collective reflection in the studio discussions. While documenting thought processes, these formalisms support beginning designers in developing attitudes of accountability for their design thinking. The whole experience is necessary for developing critical reflection.

The thesis provides an interdisciplinary context of accountability for design reasoning as an attitude in design education. It frames the value of accountability in design regarding the transparency of processes and the social practice of design. The thesis offers a theoretical and conceptual framework for implementing and assessing attitudes of accountability through computational methods. It builds a case for the methodological impact of computation on mediating the socio-ethical conduct in design studio interactions in architectural training. Within the scope of the thesis, a sequence of studies was performed in a foundation studio. The methodology of the design studio dwells on reflection conducted in a collaborative setting as two conditions for implanting attitudes of accountability among learners. The studies show that a rule-based approach to design incites accountability attitudes among learners even in a short period. What comes below is the rationale of this study, highlighting the concern of cultivating attitudes on top of disciplinary and technical aptitudes. The following parts reveal the unexplored potential of computation for implanting attitudes of accountability in early-design education, as necessary for responsible designers in the age of computing.

1.1 Cultivating Attitudes, for Designing, with Computing

Attitudes, knowledge, and skills are the overarching competency categories sought in learning (Adam, 2006). As tendencies and habits drive personal behaviors and thinking patterns, attitudes give direction to what one does with their knowledge and skills. In the context of architectural design education, attitudes are related with value-based decision-making (Hulstijn & Burgemeestre, 2015). This embodies, but is not limited to, accountability within a shared value system. Transparency of the values adhered to and accountability of decisions directly shape the social interactions of designers. A computational way to cultivate this attitude in architectural design education is the subject matter of this study.

As digital media and technologies transform the means, processes, and modes of communication and production in architectural design, architecture programs are continuously incorporating the learning of new skills in attempts to embed *the digital* in the curriculum. As the emphasis is on the technical content, however, the effect of learning these skills on attitudes has not yet been adequately explored.

The digital in architecture is the subject of a research field often referred to as computational design, covering a wide range of topics from CAD and fabrication to simulation and performance optimization. Computation, in this broader area, is a way of materializing the reasoning processes in the design (Stiny, 2006), regardless of whether a computer is used or not. This study considers that this externalization of reasoning provides transparency in the interactions between stakeholders and supports the desired accountability in the training process for a designer. This part reveals this potential of computation in the implementation and evaluation of accountability as an attitude in early design education with transparent interactions in the studio.

Attitudes, as the complement of knowledge and skills in education, are tendencies and habits that drive personal behaviors and thinking patterns. While attitudes as the affective category of learning outcomes have existed in the literature since the '70s (Krathwohl, Bloom, & Masia, 1973), their epistemological framework is broad and varied (Clanchy & Ballard, 1995). Affective educational outcomes generally entail changing or developing values like compassion and understanding, morality, or appreciation for others (Ewell, 2001). Attitudes provide a basis for expressing the values of the community one belongs to; thus, a pedagogical approach ideally enunciates attitudes to cultivate ethical values. In the design education context, the formation of attitudes partly relates to the learning of the ethics of design practice and its issues, such as knowledge sharing and consequent accountability in design (Hulstijn & Burgemeestre, 2015).

Attitudes remain a significant complement of skills and knowledge in education research, though assumed to be implicit in curricula (Bergan & Damian, 2010). This is not different in architectural education. Attempting to absorb the digital in the tools and the modes of communication in design, architecture programs are continually incorporating the learning of newly relevant skills. The technical weight of learning information and interactive technologies overlooks what kind of attitudes are simultaneously fostered. Today, as the means and methods of design and making are evolving fast, training primarily reliant on disciplinary skills is up for questioning in a competency-centered education of integrated knowledge, skills, and attitudes.

The ever-growing need for knowledge-sharing and consequent accountability in collaborative design practice is parallel to advancing information tools and corresponding technical skills of our time. Digital technology has been deemed a

potential to enhance social aspects of design processes before (Mitchell, 1995). With a critical position to these visions, the motivation behind this thesis is to build a case in architectural education for the methodological impact of computation on approaching design as a social act of creation. The values of accountability and sharing are framed concerning transparent processes and the social practices of designing. The frame of reference extends to practice, but the focus is on learning that precedes this kind of practice.

1.2 Attitudes of Accountability

Accountability reflects the character of social acts produced to be "observable and reportable" (Garfinkel, 1967). In design, it is the competence to have an argument for the execution and the reliability of the outcomes. In search of which values to aim for, existent studies focus on the ethical values of design for social objectives (Manzini & Rizzo, 2011; Thorpe & Gamman, 2011) or design outcomes' value to the social realm (Tromp, Hekkert, & Verbeek, 2011; Tromp & Hekkert, 2016). This research turns to the values which inform a designer's conduct towards colleagues in the design process. Values of accountability and openness are desirable attributes of an individual or entity (Hulstijn & Burgemeestre, 2015). Making the process visible to its moral ends has ethical implications.

There has been limited systematic research of ethical issues in design. However, discussions on the ethical dimension of design surface as new forms of technology get incorporated to design. There are four ethical dimensions inherent to design that enhance the value of a designer's work but also stir potential moral conflict. Ranging from a designer's character/personal values, the integrity of performance, product integrity and the valuable service to human beings (Buchanan, 2005), these dimensions characterize the ethical and moral in design.

Design ethics relates to moral conduct and making responsible decisions in the design process. Literature on design ethics offers an extensive range of issues. Key issues are professional ethics in general (Fox, 2000); ethical decision making (Wasserman, 2000); social responsibility dependent on a person's particular expertise. (Herkert, 2000); the designer as the moral agent (Fisher, 2000; D'Anjou, 2010); ethics as materialized in the designed (Fry, 2006; Tonkinwise, 2004) or the intersections of

technology, design, and ethics (Verbeek, 2011), focusing on design that is responsive to values (van den Hoven, 2015).

This study relies on two positions of how ethics and design relate to each other. The first is the inner ethics (Mitcham, 1995) embedded into the design. In this view, designing is a form of ethics. A designer's responsible architectural practice might generate ethical courses of action (Buchanan, 2005). Additionally, ethics is a form of designing (Whitbeck, 2011), open to creative interpretation on behalf of the designer. Thus, cultivating ethics within design begins with the attempt to articulate guidelines for the action called designing. A designer's conduct is oriented toward the production of the nontangible, like the process of designing. Accordingly, the focus is on the ethical implications concerning all the products that serve human beings. The practice of design includes the ethical courses of action and accounting for that conduct to others and society at large. This perspective calls for design students to be aware of reasoning and to embed it in broader structures of action, rather than simply learning decision-making practices on the job. This is in line with Herbert Simon's view on design as a systematic discipline involving choices aimed at transforming existing situations into preferred ones, so ethics is usually framed in decision-making processes.

Current pedagogies opt for increasing the awareness of responsibility in future professional behavior. Efforts in architectural education to develop ethical attitudes necessary for professional practice are limited. Goals for ethics teaching are clearly described (Aközer & Aközer, 2016), and most higher education institutions address ethics "across the curriculum" (Matchett, 2008; Davis, 2004). Some integrate ethics to learning for contributing to developing an awareness of values and reflective skills (Ozar, 2001). Usually undertaking ethics in freestanding courses (Herkert, 2000) or case-based teaching (Whitbeck, 1996), pedagogies of ethics offer much but do not specifically address the type of design actions performed in the design studio. Research specific to the design domain emphasizes environmental attitudes in design education for future responsible behavior in the profession (Eilam & Trop, 2012; Monson, 2005).

As the design process gradually moves from individual to collective agency, the transparency and accountability of persons or organizations operationally expose the design reasoning to all actors of the design process. The principles of accountability

and openness are also operative as they invoke the making of reasoning explicit. This awareness yields to predispositions of how to act, i.e., attitudes.

1.3 Computation to Foster Attitudes among Learners

The transformation of information and interactive technologies has affected design tools and modes of communication in design. Many collaborative design activities take place through interacting and exchanging information on shared digital media. Software producers are constantly developing parametric applications which support parallel processes allowing collaborative teams to work together. The new digital practices are shaping project management by transcending time and distance problems (Burry et al., 2001; Holzer et al., 2007). Digital design technology has been viewed as a support for social or person-to-person communication, discussion, and reflection in design processes (Mitchell, 1995). This potential is either unintentional or implicit in the early years of architectural design education. The need to cultivate attitudes of sharing knowledge in design education is crucial to parallel the advancement in tools and correspondent technical skills.

A growing number of first-year architectural design studios incorporate computational design skills that primarily focus on the use of fast-evolving digital tools to model, represent, and produce design ideas. Occasionally, computation is introduced as a rule-based visual tool for students to externalize their design processes step-by-step and part-by-part (Stiny, 1980; Özkar, 2005; Knight, 2012). However, there is not much research done on attitudes supported by such computational approaches in design education. This shortcoming may be partly due to the presumed distance between abstract computational design representations and what they imply for peers and society in general (Ostwald, 2010). Differently, this study considers that visual computing encourages openness about design reasoning, sharing, answerability and thus serves the social processes of design. Framing the value of accountability in design with regards to the transparency of processes and the social practices of designing, this study builds a case for the methodological impact of computation on mediating the socio-ethical conduct in design studio interactions in architectural education in order to pave a way for further exploration of how attitudes may be conveyed and assessed.

The thesis explores how a design curriculum for first-year architecture studios can address attitudes of sharing knowledge in collaborative practices. This view relies on the premise that knowledge-sharing leads to better opportunities for reflection while learning together. There is ample literature that focuses on how reflection-based learning contributes to professional, ethical training. Reflective practice is a reference to the teaching of business ethics (Hedberg, 2017). In design education, reflective practice is deemed essential for responsibility towards sustainable design as professional ethics (Leerberg, Riisberg, & Boutrup, 2010; Lilley & Lofthouse, 2010). Most of the design-related literature links it to moral responsibilities towards end-users.

Reflection has been one of the central concepts of Donald Schön's influential work in design education and design studies. Schön's reflection-in-action and reflection-on-action models imply thinking about the process and its consequences during and after, respectively. The latter, reflection on a done deed or process, facilitates the learner's awareness of oneself and if done openly, of other peer's knowing and learning. For this reflection to occur, the process or product needs to have been materialized. When a process is externalized and shared with the members of a community, feedback stimulates rethinking of what has been done and recreating it with a new idea.

Reflection in design studios is highly influenced by the curriculum, the immediate physical and social context, as well as the overall studio culture in architectural education. The design studio is characterized by collaborative learning. Collaboration implies that design is a fragmentable process. It allows many individuals to share, interfere and reflect at different stages of learning. It helps the learner to develop an awareness of oneself and of peers' knowing and learning. Therefore, the purpose of reflection moves beyond problem-solving or recollecting previous actions, inciting attitudes in design education.

1.4 Thesis Content

Chapter 2, "Addressing Attitudes of Accountability in the Age of Computing," first gives an overview of the notion of accountability which denotes the exchange of reasoning for conduct. The focus is on the social practice of being accountable to others rather than self, as the individual's actions have social consequences. The ethical implications and limitations of accountability, in general, are discussed. The

subsequent section delineates three contexts that address accountability as the quintessential attitude for design practice and education. The following part draws out some existing efforts in how these attitudes are instilled in design education. Finally, computational design is introduced as a means for reflection, contributing to sharing with accountability.

Chapter 3, "The Multi-Dimensional Construct of Attitudes," discusses the different connotations of the attitude concept discussed from disparate contexts: higher education, social psychology, and the recent design studies. In a holistic view, learning integrates knowledge, skills, and attitudes, which comprise the learning competencies an individual should attain by the end of a learning process. Attitudes are a disputable competence in terms of addressing and assessing them. This part traces the emergence of attitudes as a learning outcome considering different epistemological perspectives. Attitudes, further articulated from the social psychology perspective, can be learned and changed if metacognition is enabled. Thinking about or reflecting on one's reasoning offers a view on how the empirical work of this study should be structured, as explained in the following chapter. Last, as treated in the design studies, professional attitudes fall short of addressing the social aspect of the design process, with some exceptions from the design attitude literature.

Chapter 4, entitled "A Study on Reflection and Attitudes in a Foundations Design Studio," the inquiry dwells on reflective thinking in early design education and how this might be evidenced through computational formalisms. The issue of accountability is addressed in three instances: a. being accountable through a design language, b. being accountable through form and form relations, c. the impact of process sharing on accountability. Visual rules stand as a design language which document thought processes and support beginning designers in developing a sense of accountability for their design thinking. Accountability in design is about thought processes and how that couples with justifying reasoning. This approach is exemplified regarding the Socratic dialogue, *Meno*. Drawing parallels to the visual reasoning in the dialogue, students enacted a version of the dialogue by producing multiple instances of the same relation, encouraging them to grasp the relation-based character of design reasoning. In the last example, design reasoning is shared and internalized in a collaborative learning setting, structured as reflection-in-action, reflection-on-action and reflection on reflection-on-action. In the final part, evidence for accountability is

sought by analyzing students' attitudes and how they appraise the processes in their reflections by employing the linguistic analysis technique.

Finally, in Chapter 5, "Attitudes and Design Technology," I overview the original contribution of the research by delineating the main arguments of each earlier chapter. It follows with recommendations and suggestions on potential future work.

2. ADRESSING ATTITUDES OF ACCOUNTABILITY IN THE AGE OF COMPUTING

This chapter explores accountability in a tripartite structure: conceptual, contextual, and empirical. The conceptual exploration answers to what accountability is as a value and as a mechanism. Parallel to existing approaches of designing for accountability, I further discuss design accountability. The subsection closes with a discussion of the limitations of design accountability. The contextual exploration is an overview of what accountability implies in context. I delineate three contexts in which accountability is addressed as a quintessential attitude for design practice and education, and how these are supported by computation. The empirical exploration sets out a case of current efforts on how design education cultivates such attitudes, among early architectural design education competencies and considering Schön's model of reflection-in-action. Finally, computational design is argued to be a reflection tool in early design education, contributing to process sharing and thus accountability.

2.1 Conceptual Exploration of Accountability

I first draw a framework of values and principles which guide a designer's approach to the profession and practice, and accountability is one of them. Below is a conceptual overview of accountability as a notion and how it works as a mechanism. The focus is on it being an exchange of reasoning and social practice of being accountable to others.

Nowadays, designers are ever more becoming the co-creators of new realities through their design practices, turning existing situations into preferred ones. For carrying on ethical practices in the Anthropocene, human values that support human action and reasoning are central to design. Contrarily to the common belief, design is not a value-neutral task as it embodies values (individual, societal, and aesthetic) related to artifacts, processes, and systems. Sometimes design promotes values to which societies and cultures subscribe. Recently, design is gaining a prominent role in synchronizing technology with values of moral and social import. Designers are increasingly recognized as professionals who address and express values in cultures

and technologies (van den Hoven et al., 2015). Existing practices of advancing ethical principles in design (van den Hoven, 2007; Nissenbaum, 2001; Friedman et al., 2006) usually pay attention to the values and concerns of end-users. Research on moral values which are meaningful in the design culture and interaction is scarce. Designers are expected to be professionally, culturally, and socially responsible through their design practice. Hence, their role extends to being accountable to some moral standards. This study highlights and explores accountability as a crucial value and attitude for social interactions in design practice.

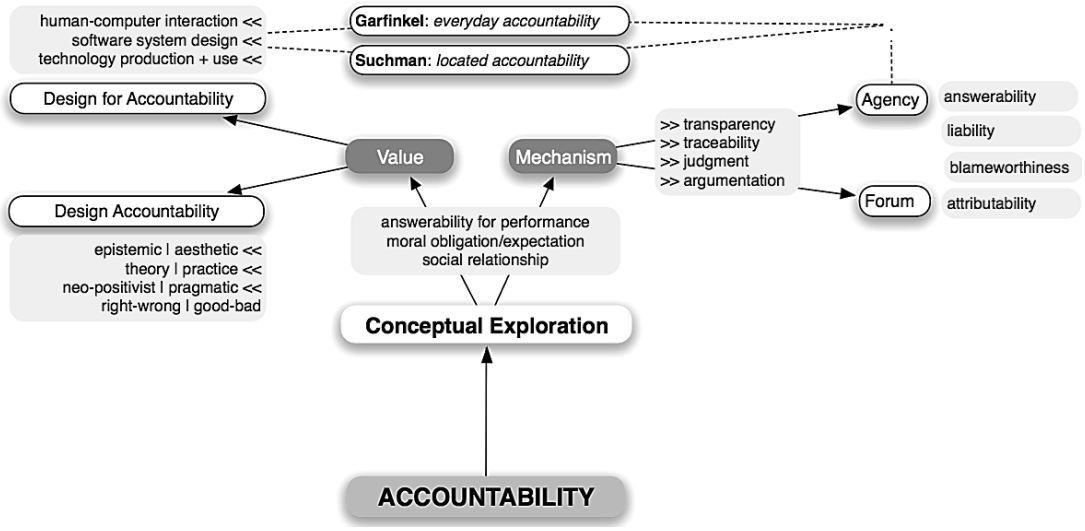


Figure 2.1 : Schematic illustration of the conceptual exploration of accountability.

2.1.1 Values

Values, as treated in this research, are standards or ideals one refers to for evaluating actions or situations, with a focus on ethics and morality. Relatedly, attitudes provide a basis for expressing the values. Values in design do not exist in isolation but in balance with other values. It calls for designers to consider the cultural context and its implications. Second, although most values tend to be held in common, a different priority is given depending on the domain and context of application. The design profession and practice have usually dealt tacitly with values that guide one's conduct. It might relate to the existing gap between the espoused and enacted values within an organization. The term organization here extends to formal or informal established units that cooperate for a common goal, as suggested by Kimbell (2011).

One of the missions of a professional designer is to seek social good, reminding of Milton Glaser's quote "Good design is good citizenship." Citizenship here stands for

a designer's professionalism, owning certain attitudes concerning social responsibility and accounting for the consequences of decisions and actions. Previously, Nelson (1957) had already related the goodness in design to a greater moral awareness for the designer's duties. He described the goodness in design as one that achieves integrity, unity, or completeness while remaining in equilibrium with its surroundings. This unity is formed in response to the opportunities and constraints of a specific environment.

The socially responsible design may come out of a human-centered approach to design that emphasizes (cultural) values. Schwartz (2006) states that values are usually consistent across cultures, but they are prioritized differently. While the priority of values is relative across diverse cultures and organizations, the core values remain intact for the design domain. At the most fundamental level design develops in response to honesty and integrity (Longstaff, 1999), empathy (as direct responsiveness to others, while being an essential part of a designer's moral imagination and deliberation) (Collier, 2006), and achieving the ideal balance between altruism and self-interest from an urban ethics perspective (Chan, 2019). Similarly, designers are expected to reflect an awareness of ethical factors such as sustainability, democracy and justice, inclusivity, responsibility, and accountability (van den Hoven et al., 2015), co-creation and sharing (Christensen et al., 2017). Other research exploring design and its relationship with social innovation promotes public and democratic values by design, such as participation, empowerment, transparency, and accountability (Manzini & Staszowski, 2013).

This study turns a spotlight on the values which inform a designer's conduct towards socially responsible design beyond the obligations and responsibilities of ethical codes of profession. This research aligns with the literature (Smulders et al., 2008; Binder et al., 2011; Poggenpohl, 2015; Kokotovich & Dorst, 2016) that views design practice as a collaborative process, situated in a social context and characterized by open attitudes of professionals. The openness towards colleagues in communication (attitudes of transparency) and accounting for past actions (attitudes of accountability) are crucial for the context of this research. They are core social values and positive attributes of a person and organization. Accountability, as a value, centers on personal responsibility and liability. It also implies ownership or authorship of ideas and actions; hence it empowers the individual. However, there is a paradoxical situation with the state of

being accountable. Accountability might be a cultural value of organizations, but not necessarily of individuals because moral values vary among individuals. Hence accountability is first a skill, which turns into attitudinal value through practice.

Below, a brief overview of accountability as a value is introduced, followed by the accountability mechanism. I delineate the different types of account giving mechanism. Accountability as answerability to provide sound arguments is the notion adopted in this research. The third subsection focuses on practices of design-related domains which have accountability as their core value.

2.1.2 The value of accountability

Definitions on the value of accountability vary depending on the context of use. Accountability is the "answerability for performance" (Romzek, 2000), either framed as an obligation (Trow, 1996) or as an implied expectation to justify one's own ideas, attitudes, and actions towards others (Lerner & Tetlock, 1999). From an ontological perspective, accountability and answerability are the conditions for becoming an ethical designer (Fry, 2006). Such qualities not only assert an ethical stance but are also operative in the design process. They invoke the making of reasoning explicit. Related to a tendency for reciprocal altruism, those who are held accountable tend to think harder and develop more complex strategies about their actions (Abadzi, 2017).

Accountability is also a social relationship (Day & Klein, 1987) built on a dialogue within a shared set of values, beliefs, and expectations. Simply put, accountability entails a relationship in which people must explain. The whole experience of accounting contributes to acknowledging oneself to the other members of a community or organization. That makes the accountability concept a social relationship by accounting beyond the self and prioritizing the others, making the whole accounting practice ethical. Accountability is a morally significant activity because demanding an account from someone entails asking that person to exercise responsibility for conduct discursively (Messner, 2009). There is not always an ethical being present amid moral performance. This divide between morality and ethics is what Aristotle called *akrasia*: to know what is proper to do but not to do it (Tonkinwise, 2004).

2.1.2.1 Accountability as a mechanism

Accountability also stands for the traceability and the transparency of one's actions, known as procedural transparency (Weber, 2008). This research relates accountability of the design process to procedural transparency as it makes explicit and understandable what guides the process and how knowledge is shared and produced. Hence accountability, combined with procedural transparency, is not an end but a mean to achieve socially responsible design. While these are essential conditions to account for personal conduct, they are not enough if judgment and argumentation do not follow.

The concept of accountability varies on the setting and the community to which one is accountable. In that respect, accountability is an ethical value as well as a social structure. Accountability denotes an attitude of the agency. It is the state of being explicit, transparent to another party. The party to which one is accountable can be a person, an agency, or even an abstract entity like an inner conscience. Accountability implies agency: agents are held accountable and not tools. It does not hinder autonomy. An accountable agent has complete freedom but might be requested any time to account. An accountability relationship is not characterized by reporting of the accounting person, but it is based on a dialogue, inclusive of judgments.

A conceptual exploration from an ethical perspective (Dubnick, 2003) distinguishes between two different conceptions of accountability. The first, embodying political actors, has been concerned with the conduct of accountability. The second group, made up of social psychologists and ethno-methodologists, has been implicated with the accountability of conduct (answerability). The later perspective resonates with the concept of reflective action in social theory. Pierre Bourdieu has given a principal place to an individual's reflections followed by Donald Schön, who integrated learning with reflection.

2.1.2.2 Types of account-giving mechanisms

Accountability is the intersection between responsibility and answerability; with responsibility concerning the future (Hulstijn & Burgemeestre, 2015) and accountability concerning the past (Yazdanpanah & Dastani, 2016). Accountability is the complement of responsibility (van de Poel, 2011), distinguishing between accountability and blameworthiness, which are both notions of backward-looking

responsibility when one accounts for past actions. Yet, accountability closely ties to the concept of forward-looking responsibility when the moral obligation to account for actions becomes an attitude or predisposition to act responsibly. Similarly, depending on whether expectations relate to persons or events, and whether they are structured or emergent, accountability differentiates into answerability, liability, blameworthiness and attributability, as illustrated in Table 2.1.

Table 2.1 : Types of accountabilities.

Expectations are	**Structured**	**Emergent**
Related to persons	Answerability	Blameworthiness
Related to events	Liability	Attributability

This research subscribes to the mechanism of accountability as answerability. Persons related to this kind of accountability are expected to account upon demand based on their roles. Role-specific account giving relate to structured social relationships. The task of account giving is inherent to the position held. In design, accountability as answerability is providing sound arguments for design decisions. For instance, the design learner is expected to account to instructors and peers because of the social structure of the studio setting. Similarly, professional designers are expected to account to any stakeholder involved in the design process.

2.1.2.3 Designing for accountability

Among many practices related to Design for Values, there are attempts to explicitly include the value of accountability in design processes of information technologies. Different from the accountability of conduct, designing for accountability corresponds to how accountability is carried out and ingrained as a value in the process. Accountability has lately emerged as a driving principle with ethical implications in computer-aided design processes. The involvement of computers is critical in fields of human-machine interaction or collaboration. (Eriksén, 2002; Friedman et al., 2002; Hulstijn & Burgemeestre, 2015). Accountability in software system designs frequently relies on human accountability for a computer program rather than software-assisted accountability. The value-sensitive design is one of the few studies that describes how accountability is integrated as a design input into an information system (Friedman et al., 2006). In this view, accountability stands as the information system's collection of attributes. It guarantees that a person's, a group of people's, or an institution's activities can be traced back to that person, group, or institution, respectively. Accordingly, the

agency should collect evidence along the way to be examined by a critical opposition or forum.

Another approach, situated within a political agenda, is when the designer explicitly supports values during a design process. The case is for UrbanSim's designers (Borning, Friedman, Davis, & Lin, 2005) who explicitly support three values in their design: accountability along with fairness and democracy.

The recent software engineering literature relates accountability to designing transparent systems as an alternative to information restriction, oriented towards "information accountability" (Weitzner, et al., 2007) or "socially translucent" online environments. Such systems support mutual awareness and accountability by making people scrutinize and replicate others' actions and engage in various collective modes of interaction like sense making and scaffolding. Accountability in this sense is closer to Garfinkel's concept of everyday accountability. Accountability is a fundamental notion in ethnomethodological research (Garfinkel, 1967) for understanding how individuals arrange their everyday conduct and communications. As a result, accountability is concerned with the kind of social acts which may be observed and reported, i.e., made available to participants as a contextual pursuit of observing and reporting.

Grounded in a similar methodological approach as Garfinkel's, Suchman (2000) explores the concept of located accountability concerning technology production and use. Differently, she explicitly relates accountability to professional design. Located accountability stems from the classical stance of design from nowhere. Suchman is critical in claiming that designers are systematically taught to be unaware of their roles within the social connections that compose technological systems, to regard technology as artifacts and themselves as their makers. The detached design process from the site of use obscures accountability and responsibility for relations between designers, the designed technology, and its use. Designs and their uses, in this view, are a collective achievement, with accountability focusing on interaction and relationships within and beyond one's community of practice.

Thus far, an exploration of accountability as a concept was given. It is a value and an issue of ethical, political, and social import. Accordingly, different understanding and implications for design arise. Beyond designing for accountability, the following part

concentrates on whether designing is accountable. Existing research (Gaver et al., 2001) distinguishes between epistemic and aesthetic accountability. However, for design the borderline is not clear-cut due to the design's ill-defined nature.

2.1.3 Design accountability: Is design accountable?

Herbert Simon (1996) attempted to build a scientifically solid foundation for good design by defining the cognitive processes linked with creativity. The suggested decision-making cycle would be logically consistent and would allow for iterative design. Simon's positivist and empiricist perspective of design as science may be contested. Likewise, one might disagree with Dewey's pragmatic principles of intentional operations in modern culture (Buchanan, 1992). The pragmatics of design practice set it apart from the neo-positivist approaches in design theory. The stark division between theory and practice reflects the neo-positivist view to design as science contrasted to the pragmatic view of design as a plural activity. The difference establishes a boundary between design and science, portraying design solely as an aesthetic discipline.

In either case, design is ill-defined, and every solution is either good or bad; the design is neither correct nor incorrect—the ill-defined design nature results in a plurality of design truths. Hence, designers should account for and justify their decisions and actions. They are expected to elicit answers providing argumentation or justifications for their design intentions.

Designers justify their activities by providing a reasonable account for the actions' goodness in terms of the appropriateness of design decisions at any given time. Occasionally, a request is made to describe the design reasoning for adopting (or rejecting) a particular proposal (Ball et al., 2001). Although such kind of dialogue does not aim to achieve consensus, it provides ground for mutual understanding. Accordingly, the ethical goal of participatory design is to recognize that design is responsible for the realities it makes (Robertson & Simonsen, 2012). Accountability is a dialectic activity involving explanations, justifications, and judgments, reasoning, and criticizing. In this respect, accountability is a mechanism of developing self-awareness, especially in collective endeavors where designers are expected to account for their point of view in the work process.

Roberts (1991) distinguishes between the individualizing and the socializing forms of accountability that cultivate dialogue and openness in a socializing talk. Other parties, such as present users or coming generations, hold designers accountable. All of them may benefit from or strive with design's outcomes and objectives. To put it another way, design is constantly answerable to a variety of different audiences.

However, as accountability is usually grounded on asymmetrical power relationships, such a condition might inhibit the dialogue. A limitation in this respect is that the accounting agency might adjust the account according to the forum when the views of one's audience are known. In the design studio setting, as the students seek the ratification of the studio instructor, students may strategically shift their attitudes to align with those of the instructors. Accordingly, accountability does not alter students' cognitive processes but rather their willingness to say what they think. It, in turn, impedes learning with accountability and even inhibits creativity. Another limitation relates to the capacity of narrating; the practice of giving an account depends on the ability to justify one's conduct. There is a limit to the unconscious information being turned into conscious information (Butler, 2005). As the design actions usually emerge in the form of tacit knowing (Polanyi, 1983), there is a limitation in converting implicit knowledge to explicit knowledge. Therefore, the limitation of justifying and articulating design arguments, limits the ability to be accountable.

The above exploration was an outline of the different connotations related to the accountability concept. It is a mechanism composed of an agency accounting to another party, the forum. The varying relationships between agency and forum differentiate accountability into several types. This thesis research subscribes to accountability as answerability. It corresponds with the designerly ways of providing arguments and judgments on design actions taken, hence design accountability. Accountability is a core value of ethical import, which meaning changes depending on the context. What follows below is a contextual exploration of accountability as an attitude in design practice and education, from a computational perspective.

2.2 Contextual Exploration: Attitudes of Accountability in Design Practice and Education

In drawing the contextual structure of the framework, three interrelated forms of accountability from the relevant multidisciplinary literature to consider in today's

design practice and education. As delineated in the literature, accountability emerges as a matter of concern in the open use of design technologies with transparent manifestations of processes in forms, and the collaborative relationships with peers and with experts. It is expected that these forms of accountability of design technologies extend to design practice, but the scope of the thesis is limited to learning that precedes such practices. To extend to practice, it would be crucial to include accountability in relationships with the users; Limited by the scope of design education, I deliberately exclude the user perspective. What follows below is the reference framework for accountability, derived from three interrelated forms of it: one, in collective action enabled by technology, two, through form itself as the manifestation of design, and three, in learning with peers.

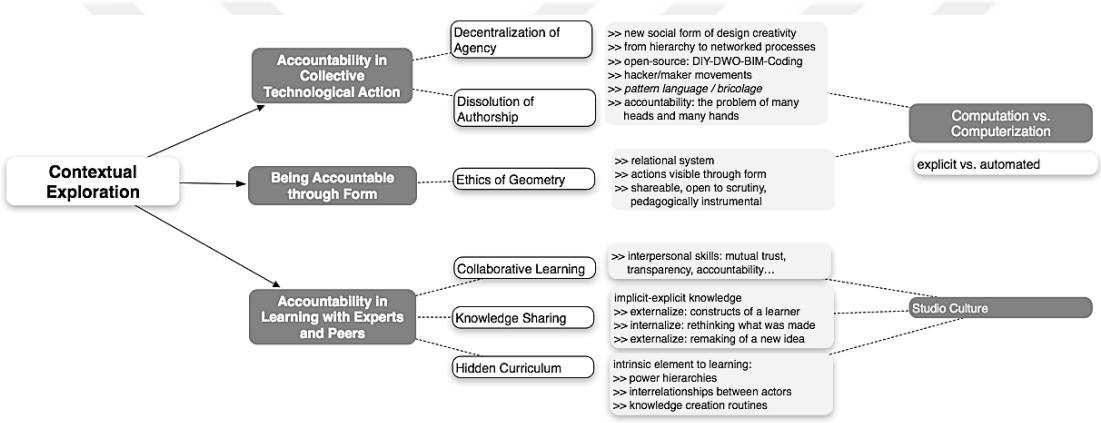


Figure 2.2 : Schematic illustration of the contextual exploration of accountability.

2.2.1 Accountability in collective technological action

Technological developments and computational approaches to design have tested the nature of human actions. These developments, as usually take place in collective settings with many agents involved, have raised novel issues in the ethical dimension of design (Johnson, 2004). The ethics of accountability becomes and important theme for the collectivity of the technological actions. Parallel to a spotlight on accountability, responsibility, and transparency in ethical AI (An et al., 2017), proponents of digital and parametric design (Leach, 2009; Schumacher, 2009) hold accountable the agents, and not the digital tools, for the core values of architectural design production: coherence, sustainability, and efficiency. Accountability becomes an issue in at least two conditions that computational approaches bring to design: a new social form of design creativity through the decentralization of agency in handling complex data-driven processes and the dissolution of authorship as often observed in

automated digital and parametric design (Carpo, 2014). Accountability in the latter is addressed when the human agents are held responsible, and not the tools. In the former, digital culture is characterized by a shared agency.

The transformation of the information and interactive technologies has affected design tools and modes of communication in design. Many collaborative design activities take place through interacting and exchanging information on shared digital media. Software producers are constantly developing parametric applications which support parallel processes allowing collaborative teams to work together. The new digital practices shape project management by helping transcend time and distance problems (Burry et al., 2001; Holzer et al., 2007). Despite the technology-fluency competence characterizing the designer of 2025 (AIGA, 2017), the human-centric emphasis on design and relevant pedagogies prevails. Mitchell (1995) had anticipated a successive paradigm of CAD research that enhances the social processes of design. Many curricular frameworks offered under the banner of 21st-century skills attempt to broaden learners' capacities to change in response to the evolving character of knowledge co-creation and sharing (Dede, 2010). The need to cultivate attitudes of accountability in collective and collaborative design practices is ever growing to parallel the advancement in tools and complementary technical skills of our time.

Transparency comes up as an issue when considering the design process from an ethical perspective. With the increase of DIY/DIWO, even the consumers must know how the designs (products) are made to take responsibility. Likewise, designers should be open about their design processes, and be accountable for their designs. Transparency is an issue of sharing authorship, the example of the Creative commons vs. Copyright model as one of the solutions to design collaborative processes. It started with the music industry, video, photographs, textbooks that might be considered as data, and recently design. Design is not opened to being accessed, but it is open-ended, i.e., open to interpretation. At the same time, the word design itself might point to a product; design switches from a product to a process when the word Open is associated with it.

Coding is a contemporary form of open-source design. It is the mode how it used to be before industrialization. The carpenters would produce the same piece of furniture without worrying about the copyright issues. Architecture stood up as a profession during the Renaissance. Alberti identified the architect as a semi-divine figure by

separating the work of mind from the work of hand. Earlier examples from the Gothic period shed light on the collaborative creative act, where the practice was conducted through fixed templates hence the digital master builder notion. The recent technological developments have flattened the hierarchical linear structures shifting to networked processes. Labeled as the new capitalist culture (Boltanski & Chiapello, 2005), it encompasses transforming hierarchies into networks, moving from bureaucratic rigidity to collaboration, and developing multiple competencies.

The design methods movement stemming during the 1960s introduced a new model of authorship, with Christopher Alexander's pattern language, followed by Colin Rowe's Bricolage as a form of holding someone accountable for one's design ideas. Furthermore, the advancement of digital technology has created new notions that challenge authorship standards. It is nowadays epitomized with the hacker and maker movements introducing new production and sharing techniques. From a perspective that focuses on the design process, the integration of digital media into architecture has opened new frontiers for dynamic forms of collaboration. The Building Information Modelling (BIM) is a sign of the transition from a single author model to collective and transparent design processes (Bernstein & Deodhar, 2015). In addition, open-source codes, DIY, and maker cultures are valued for the democratization of technologies (Tanenbaum et al., 2013), because they enable designers to learn by sharing, comparing, and collectively building up information.

The transformed authorship poses a challenge to the concepts of ownership and consumption, becoming the contemporary discussion of the "tragedy of the commons." Similarly, the increased computerized collaboration may blur authorship and take away from the accountability of individuals in collective action (Nissenbaum, 1996). Nevertheless, computation is different from computerization, and it makes the design process explicit rather than automated. The increased collaboration in practice requires an understanding of computational design as an attitude of transparency in actions and interactions of the design process.

2.2.2 Being accountable through form

In parametric modelling that is supposed to be more than a mere automated form-finding tool, the model is instrumental at explicitly defining some of the reasoning leading to the outcomes. it is possible, however, to also adhere to visual definitions in

computation rather than solely to the numerically and symbolically defined parameters in design. Forms maintain the "ethical traces" (Lachterman, 1989) or the transparency of their construction process. Geometry systems have generally been used to transparently comprehend and communicate the underlying relational systems. Derived from Aristotle's (*ta ēthē*), Lachterman's definition of ethics refers to values which define individuals' attitudes revealed in the ways they operate in society. Due to these reasons, the underlying relational systems of how forms relate in designs at various levels of complexity, reflect the ethical attitudes of the designers. Nowadays, computational design has enabled increased complexity of geometries in form-finding and form-generating processes. Contrary to the general belief, the designer is less aware of the geometry behind the forms, compromising the ethical implications of the tools and processes.

However, from another perspective, if aspects of the design process are visible through form, they are shareable, open to scrutiny, and pedagogically instrumental towards encouraging accountability. The illustrated example in Figure 2.1 shows some underlying geometric relations between shapes perceived in both the figure and the ground. These visible clues might serve as a tool to convey the knowledge of how these shapes come together to peers. Visual representations of a design computation via shape rules embody these visual parameters and references (Knight, 1994), and help one to trace the transformations of designs.

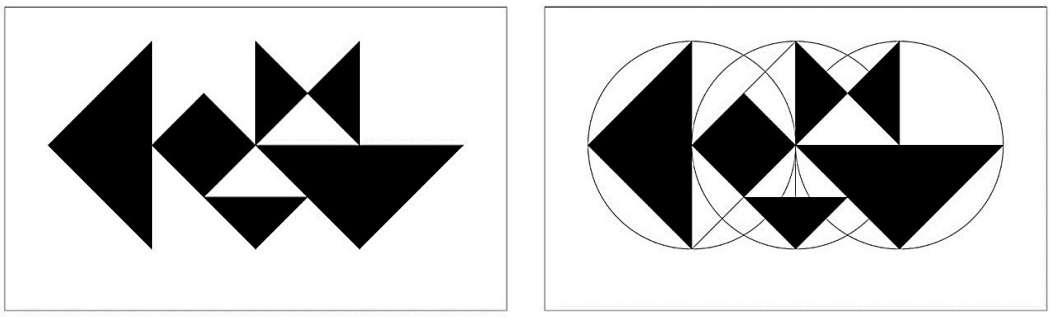


Figure 2.3 : A comparison between a first-year architecture student's composition of 2D shapes and the same composition with its referential system (Fall, 2019).

Buchanan (2008) similarly considers form as an operational tool to address attitudes and values in design. A transparent design process is shareable, open to scrutiny, pedagogically instrumental, and accountable. Hence, an ethical design process is when a designer's actions are made visible through form and thereby may be held accountable.

Another consequence of the computational shift is that parametric generation of many forms seemingly obscures authorship and dissolves the designer's responsibilities (Ostwald, 2010; Carpo, 2014). Nonetheless, one can argue that the explicit ways in which forms are designed to emerge make the process computationally understood and not necessarily automated.

2.2.3 Accountability in learning with and from experts and peers

In higher education today, learning is regarded less as a stand-alone act and more as a collaboration with peers that brings together experiences, insights, and instruments (Crosby & Morgan, 2016). Learning environments are based on interpersonal and group dynamics with collaboration and knowledge sharing between students. Along with flexibility, adaptability, and self-direction, accountability is deemed one of the non-cognitive skills that drive guiding the interpersonal relationships between students.

The pedagogical paradigms like Bauhaus were focused on the know-how of skill development. Today the new learning should be grounded on the discussions of the know-why to foster a self-reflective attitude by motivating accountable actions in the classroom and beyond (Bennet & Vulpinari, 2011). These reflections do not list a set of competencies that a designer should have to fulfill his or her role successfully, but rather prepare the ground for formulating these competencies.

Accountable practices of design learning involve sharing of knowledge in collaborative and social contexts, attending to the hidden curriculum of the design studio culture. Tracing accountability in collaborative practices, in knowledge sharing and the hidden curriculum of studio culture, these aspects promote or impede accountability in learning.

2.2.3.1 Accountable collaborative learning

Collaborative learning is an educational strategy where learners of different skill set work together for a shared purpose. It fosters mutual trust, personal responsibility, and social competencies as a partnership for learning. Similarly, design practice is a socially collaborative process characterized by the extra abilities that enable

professionals to collaborate, listen to, and learn from one another while solving issues (Smulders et al., 2008).

Collaboration is not working with somebody who thinks like you but the coexistence of contrasting values (Lloyd & Oak, 2018). In his seminal text on collaboration, Kvan (2000) observed that "simply working together does not make the act collaborative." Recent research (Carraher et al., 2017) claims that collaboration in design is both a strategy that harnesses collective knowledge and a culture sustained by interpersonal skills of trust, transparency, and accountability (among others). Accountability is, above all, a social relationship in which one may have "the moral obligation to account for what happened" (van de Poel et al., 2015) to all other stakeholders. Accountability and sharing are mutually dependent in this view.

Collaborative learning in design is very much related to viewing design as a complex process, which allows many individuals to share their ideas and play essential roles in different stages of learning. The process of externalizing knowledge by sharing in a collaborative setting becomes essential to the development of an individual. It stands for the approach that this study takes.

2.2.3.2 Knowledge sharing in learning

The knowledge sharing in learning is both the dissemination and exchange of explicit or implicit knowledge, ideas, experiences, and skills from one individual to another individual student or group of students (Wei et al., 2012). In architectural education, the studio set-up brings together individuals who produce and reflect in parallel. The multiplicity of ideas, methods, and perspectives are shared and learned directly or indirectly from peers. The resulting comparisons initiate reflections on processes of one's own as well as other students' processes. Recognizing moments of knowledge sharing becomes part of one's social accountability.

According to the constructionist viewpoint (Harel & Papert, 1991), the constructs of the learner are external and shared. Learning requires externalizing a process or product for feedback with different cultural groups or peers. Materialization of thinking facilitates rethinking what was made (internalizing). Sharing and internalizing enable the remaking of a new idea (externalizing). Schön's seminal work (Schön, 1983; 1987) provides a framework of reflective practice which translates the theory mentioned above into action for a learning setting.

Often considered a form of knowledge transfer and evaluation, studio critiques serve as a form of accountability (Wolf et al., 2006) and encourages students to value and respect peer judgments (Oh et al., 2013). However, in this mostly one-directional transfer between the expert and the novice, it is where students are practicing accountability for their design decisions in an asymmetrical power relationship. Alternatively, peer review sessions have been shown to empower the students (Dutton, 1991) more than desk critiques provided by the instructors. Peer interaction supports collaboration, sharing, interference, and reflection in learning.

Although the studio setting, as a place, is recognized for its social interactions and collaboration it promotes (Valkenburg, 1998), the latter is not the default but an option in the pedagogy of the studio (Kuhn, 2001). Studio culture reflects the values of its specific community (community of practice), generated by the pedagogies and interactions among students and faculty. Culture reflects the values of certain community, in which case generated by the pedagogies and interactions among students themselves and faculty.

Although the studio environment also encourages students to be learning from each other, design education where individuals' skills are openly praised fosters competitive situations (Anthony, 1991; Dutton, 1991; Cuff, 1992; Koch et al., 2002). The student is isolated from the rest of the studio environment because of the individual practice of architecture and pursuit of original ideas overrides collaboration. Students often are hostile to their peers, frequently protecting their ideas from each other while competing for the studio critic's ratification. The competitiveness among peers and the imbalance of power between students and instructors is often the hidden curriculum of the studio. These aspects inhibit the desire for dialogue and collaboration among peers and impede the development of accountable attitudes.

2.2.3.3 The hidden curriculum of studio culture

The term first introduced by John Dewey in the early twentieth century was further expanded by various educational theorists, notably in the 1970s, as a tool for reflecting on the dialectical link between pedagogy and politics. It involves an indoctrination of the student body, where faculty act as role models in transmitting the hidden curriculum by favoring certain types of students based on hierarchical social relations.

The hidden curriculum promotes everyday learning practices as an intrinsic element of the educational process with equal effect as the core curriculum. Some of the activities include, but are not limited to, power hierarchies, interrelationships between diverse actors involved in learning, and knowledge creation routines. This theory holds that educational procedures implicitly embed and convey particular values and attitudes implicating its own power relations. The unequal power dynamics that exist in society between genders, ethnicities, and classes are replicated in the classroom.

Contrarily, (Martin, 1976) had previously stated that hidden curriculum, in general, is tied to learning and not to schools. She considered the hidden curriculum a set of learning states aiming to acquire attitudes and values while imparting knowledge and skills. Hence, students should arrive at a conscious level to understand what is learned because of the practices, procedures, rules, and relationships which constitute a learning setting or culture.

Most of the main characteristics previously described are essentially socially created through the cultural qualities that emerge from the architectural design studio. There needs to be evidence that studio culture values might be integrated into learning and studio pedagogy, and its effects should be measurable. At issue are the formations of desired attitudes that arise from the social setting and the course content, including pedagogy, student learning, collaborative practices resulting in positive studio learning experiences. While there is no exclusive list, some of the values and attitudes commonly cited in higher education literature include a feeling of social duty, sensibility to morality, tolerating and respecting human dignity (Bergan & Damian, 2010). Similarly values such as “mutual respect, collective action, and compassion” (Mull, 2016), when introduced in educational models would result in less pressure on students.

These forms of accountability help this study draw a framework for a pedagogical setting to cultivate attitudes such as transparency and answerability in design education, especially from the early years. Externalization of reasoning processes and design ideas is necessary for building a culture of seeking meaningful feedback from peers and experts. Technological approaches, in the form of computation that externalizes and articulates the design process, can be useful for augmenting the reflections and interactions in a pluralistic and collaborative environment.

2.3 Empirical Exploration: Instilling Attitudes in Learning Experiences

In architectural design education, it is not easy to open up accountability as an attitude to keep the design process. Attitudes are usually acquired in tacit learning. Following this assumption, this study looks for the means to support the conditions which the three forms of accountability delineated above rely on in the first-year architecture education: tools to externalize the reflection-on-action and a collaborative setting.

The empirical exploration looks at practical actions already taken in education literature. This is the exploration of what is being done for instilling professional attitudes that are essentially ethical. The perspectives of design as a reflective process are rooted in the philosophical tradition of Dewey (1933). He saw reflection as a mode of inquiry, demanding intellectual attitudes which are intrinsically ethical and moral. Hence, reflective thinking is a method to foster attitudes, and attitudes are necessary for reflection to materialize. The research is grounded on reflective practice and concerns the ethical and social values cultivated during a design process. These explorations help the study draw a case by introducing computational design thinking as the means to professional and reflective attitudes.

2.3.1 Ethical attitudes

Recent years have seen a renewed emphasis on ethical attitudes in professional curricula like medicine, law, and management. Ethics as an indispensable part of the professional education curriculum reflects the role of the professions in the conception and the creation of the "artificial" (Simon, 1996). The relation between ethics and design usually stands for the professional rules of conduct and how they help resolve the ethical issues from a legal perspective. Consequently, the discourse of ethics tends to focus on codes of conduct and standards of practice: how designers as professionals relate to colleagues, clients, and the end products. Furthermore, the traditional discourse of ethics concentrates on assessing actions already taken (Whitbeck, 1996) by making moral judgments of right and wrong. However, ethical situations show competing but equally persuasive values not necessarily differentiated by right and wrong.

Thus, rather than defining a single proper way of conduct, ethics may be a process of developing practical answers to issues (Moore, 2014). This idea resonates with the "satisficing" approach to decision-making in the design disciplines (Simon, 1996).

Comparably, design students should develop an awareness of situating such reasoning in larger structures of action by not limiting the ethical reasoning to decision-making only. This awareness yields to predispositions of how to act, i.e., attitudes. D'Anjou (2004) proposes a framework to integrate ethics into professional education, as he defines the professions as "the material embodiment of human intentionality."

The focus on ethics and its values for human conduct has emerged in the higher education level of professional disciplines intending to make the students deal with real-life professional problems. Professional ethics stands for the moral obligation based on an individual's specific expertise (Herkert, 2002). Design education can support developing ethical thinking abilities, such as the capacity to consider others' viewpoints, foresee the implications of an action, training judgment, and responsible decision-making. Design education is practical, in the same way that ethics is. Both design and ethics share similar attributes: they are action-based practices. Increasing the sensitivity of student designers to the ethical dimension of their practices requires a situational "learning by doing" approach (Findeli, 1994).

Apart from the responsibility as a designer, the instructional orientation of learner-centeredness in design studios is suitable for implanting the notion of responsibility as a learner (Monson, 2005). Accordingly, the learner-centered approach supports the disciplinary position that design reasoning is subjective, independent, and reflective. The situational and the constant explorative learning process followed in the architectural design studio is preferable to increase the sensitivity of novice designers to the ethical dimension of their practices. While professional ethics embodies micro ethics, differently, Findeli (1994) argues that design education should operate on a second level, macro ethics, which concerns the general morality of the students so that they develop a general attitude even outside the design domain. Design ethics applies to moral behavior and responsible choices while practicing design, placing the designer as the moral agent at the focus of ethical thought.

According to a framework on learning competencies (Meijers et al., 2005) developed by the Dutch universities of technology: Delft-Eindhoven-Twente, hence the 3TU system, attitudes are an aspect peculiar to Master level competences, different than skills which are always associated with knowledge for a university graduate. A Master's level student should possess the necessary attitude to know when and why to apply the knowledge and skills. Based on the designer's growth competency model

(Hummels & Vinke, 2009), design students achieve a professional attitude characterized by social responsibility towards the end of the bachelor's program. Similarly, Lawson and Dorst's (2015) generic model of competence suggests that attitudes are formed at the master level of expertise and characterized by disciplinary and professional awareness.

Contrary to these views, the study posits that attitudes may be implicitly introduced in the initial periods of design education, along with disciplinary expertise, if reflection is enabled. Students will learn how to do something, but they will be competent in using the gained knowledge and the developed skill in relevant learning, social and latter professional situations. It indicates that attitude formation is an individual as well as a collective process.

The responsibility characterizes professional attitudes acquired in undergraduate programs as a designer. However, there is little on the social aspect of the designing process and how reflection contributes to that. One exception is the recent design research literature that focuses on design attitudes in management (Boland & Collopy, 2004; Michlewski, 2008). It follows Buchanan's (1992) introduction of the role of designers as reflective thinkers to the organizational fields, expanding design attitude to the human aspects of designing. These design perspectives as a reflective process are rooted in the philosophical tradition of Dewey (1933). He saw reflection as a mode of inquiry, demanding intellectual attitudes which are intrinsically ethical and moral. Hence, reflective thinking is a method to foster attitudes, and attitudes are necessary for reflection.

2.3.2 Reflective attitudes

Reflection is a troublesome concept. There exist varying connotations to the term, depending on the theoretical perspective. Dewey (1933) considered the reflecting activity as a subset of reasoning, Habermas (1971) related reflection with the process of knowledge construction, (Wittgenstein, 1992) associated reflection with ontological shifts that he called as *seeing-as,* and Arendt (2018) called it a *stop-and-think* reflection taking place in the medium of the words. Schön's seminal work (1983) provides a framework of reflective practice for a learning setting. A later variation of this model frames reflection in sketching (Goldshmidt, 1991) by alternating between *seeing-as* and *seeing-that* as two forms of argumentation in design thinking.

Sharing initiates reflections on others' thinking processes. That sharing initiates reflections and reflections must be shared to become reflections is easy to miss because reflections are frequently viewed as intrinsic activities of confined persons, which might explain why individual designer studies have provided the most insights on design activity and processes (Cross & Cross, 1995). Similarly, Schön's *reflective practitioner* is criticized for his solitary character (Webster, 2008; Tonkinwise, 2004). It is essential to recognize that other dimensions to learning in the design studio are also referred to as studio culture.

Differently, Dewey (1933) had long ago acknowledged reflection such that it must take place in a social context and interacting with other members. He was concerned with cultivating attitudes of reflective thinking for a broader purpose: the character development of the learner. Accordingly, reflection is a mode of inquiry that shifts the learner from one experience to another with a deeper understanding while interacting with a social group. He developed the idea that only what is acquired in practical reflection can be applied in subsequent reflective practice. Dewey saw that reflective practice demanded intellectual attitudes which are intrinsically ethical and moral, like open-mindedness and responsibility. In this view, attitude development is related with the ability to train thought and judgment; there is no separation between mind and character. Hence, reflective thinking is a method to foster attitudes in an educational setting, and attitudes are necessary for reflection.

2.3.2.1 Schön's model of reflection

Reflective thinking is usually attributed to Schön through his reflection-in-action and back-talking with the material in hand. It is an alternative epistemological approach to professional knowledge development as acquired from experience. The conversational sequential structure of the see-move-see cycle (Schön & Wiggins, 1993): one sees what "there" is, acts concerning it, and sees again, informing further steps. The idea of *seeing as* has an important place in Wittgenstein's Philosophical Investigations (McGinn, 2013) and Max Wertheimer's approach on finding the area of parallelogram, dropping an altitude from the vertex and meet with the baseline forms a triangle. It starts with passive knowing, in Polanyi's terms (1969), followed by surprise. It is the surprising moment which "generates new forms of understanding" if the enquirer reflects on the result of the action.

A good example of reflection in action is Jackson Pollock drawing with the drip technique. One mark on the canvas informs the next step. Alternatively, the jazz player improvises based on a shared understanding with the other musicians. Reflection in this sense resonates with Hannah Arendt's "stop-and-think" (2018) moments (which take place in the medium of words); Sylvia Scribner (Scribner, 1987) and the milkmen example who used the units' box as a tool to think with, by recognizing different patterns.

For Schön, one could also reflect on reflection-in-action, arguing that it generates new knowledge, not only applying it. The origins of reflection may be traced back to Plato's *Meno* dialogue through parallelism between recollection and reflection. Kant later treated reflection in his *Critique of Practical Judgment*, but the pragmatists' interpretation of reflection is more relevant to Schön's notion of reflection. The designer's capacity to notice changes and refocus his strategy based on the situation's "back-talk," thereby creating additional ideas, is critical in the reflective thinking process. According to this point of view, the designer does not begin each design with a blank slate but instead uses previous understandings. Differently, Mitchell addressed reflective thinking as valuable when the reflective thought is directed on the work of others, along with self-criticism on one's work, leading to stylistic evolution (McCullough et al., 1990).

New research (Beck & Chiapello, 2016) reveals that the work of Schön is generally undisputedly quoted without elaborating on its concepts. The work of Schön is generally undisputedly quoted without elaborating on its principles. This study recognizes and criticizes Schön's views despite the uncritical usage of the idea of reflecting in design studies. It is in support of Schön's work as there is an accountability dimension inherent in reflection. He offers a theory that explains the acts of a person by reflecting and acting as two aspects of the reflective practice. The relation between the two is that the practitioner can produce various frames of reflection-in-action during a reflection-on-action stage. Reflection-on-action is the reviewing that occurs after an event, whereas reflection-in-action is part of a competent practitioner's thinking while doing (Moon, 2001).

However, some counterviews to Schön claim that it is an over-generalized, not scientifically proved argument (Webster, 2008). It does not account for the uncertainties of reason and its effect on reflective inquiry (Spencer & Hilton, 2010). It

fails to address the time variable and the features of the context (Eraut, 1995; Ixer, 1999). Accordingly, reflection is always on-action, rather than in if the time variable is taken in consideration.

Reflection is a social process, highly influenced by the curriculum, the context, and studio culture as in architectural education. The students' learning experiences form through activities like individual or panel reviews, collaborative group work, and any other interactional activities situated in the design studio. This environment is characterized by collaborative learning, which stands for viewing design as a fragmentable process. It allows many individuals to share, interfere and reflect at different stages of learning. In this view, this study acknowledges that there is a meta-cognitive dimension inherent in the process of reflection. It helps the learner develop an awareness of oneself and other peers' knowing and learning. Therefore, the purpose of reflection moves beyond problem-solving or recollecting previous actions.

2.3.2.2 Tools and strategies for reflection

Generally, reflections are articulated in different formats in the design studio, depending on the competence to be acquired. In addition to pin-up reviews, forms of reflection can be student portfolios, journals, weblogs, and showcases. These forms serve as tools to monitor and self-reflect on one's learning and development. They are also regarded as tools to encourage individual student accountability (Shupe, 2008). Usually, the assessment of these forms of reflection is left to the students alone and may not always result effectively as the student might lack the motivation to self-reflect. Similarly, Ewell (2001) claims that a drawback of these tools is that they are usually employed as an "add-on" rather than embedded to the course's instructional design. Their effectiveness on student accountability depends on the course/program expectations. Involving experts and peers in the reflective process ensures that learners are aware of what they have learned and triggers the intrinsic motivation and attitude to carry out further self-reflective activities. Strategies to disseminate the content include group discussions and practicing through role-playing. In a similar approach with role-playing, design students are considered "junior employees" (Hummels & Vinke, 2009) who act out professionally and are engaged as full-time in the department. The aim is to instill attitudes of responsibility and professionalism.

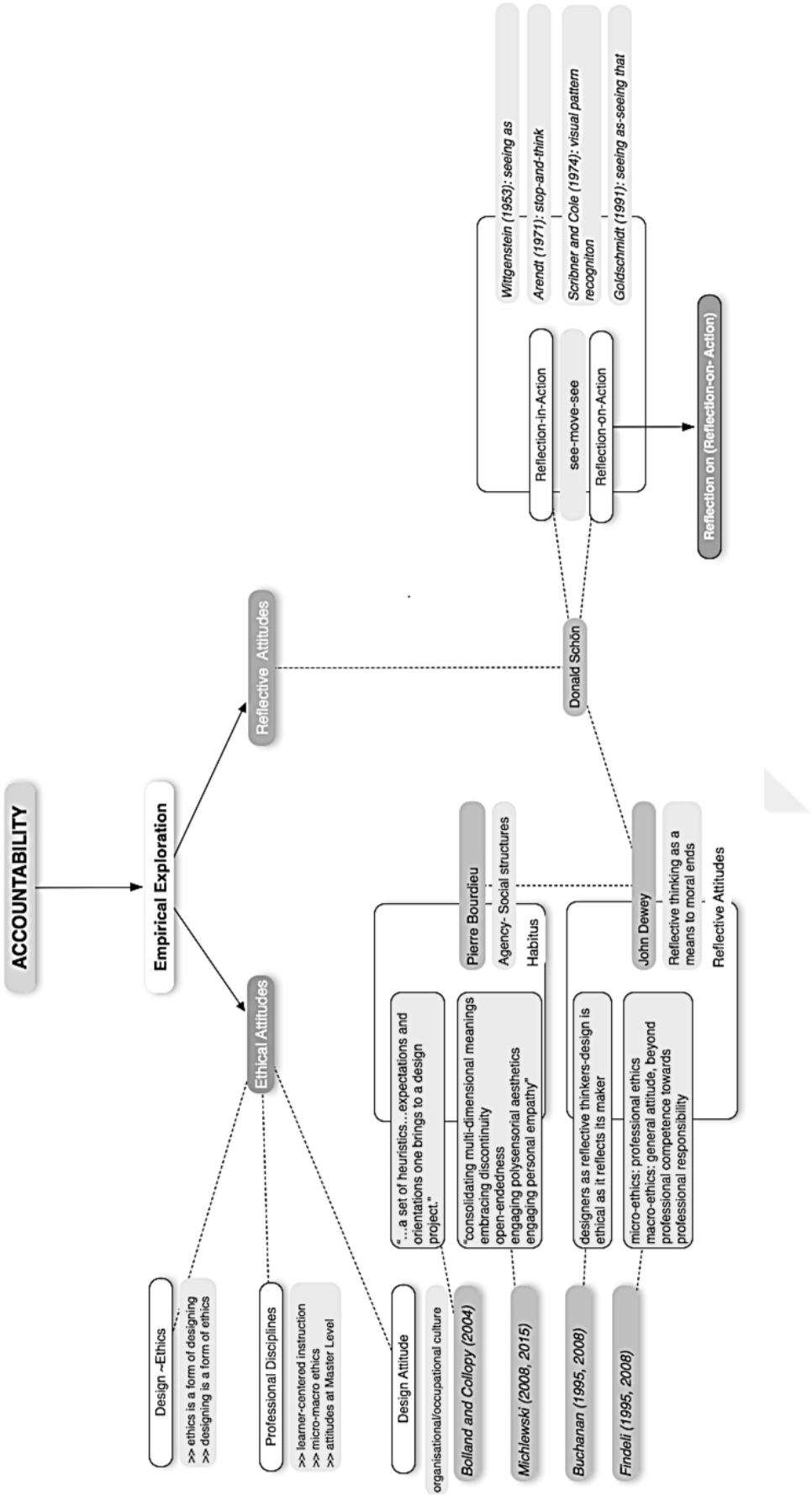


Figure 2.4 : Schematic illustration of empirical exploration of accountability.

Construction and professional practices are an example of simulating the real-world design profession. Other research from participatory design (Frauenberger et al., 2015) show that accountability is delivered through debate, critique, and reflection. This approach resonates with the design critique tradition of studio courses, consisting of a two-way communication on design judgments and decisions where students are encouraged to construct solid arguments and share their knowledge in an explicit manner (Schön, 1985).

In this context, foundation design studios are reminiscent of learner-centered pedagogies. Moreover, reflective learning supported by such pedagogies is consistent with design nature as well. Fundamental to reflection in professional knowledge and education, is that students construct meaning by reflecting at various instances on their design practice. Students usually reflect at various moments in their regular course of learning, but the aim here is to develop an awareness of self-reflection.

If reflection reveals the form of accountability in learning from peers and experts, the tools of reflection encourage accountability in collective technological action, particularly one that focuses on visual computing with shapes. A recent tool for reflection in design education is the visual formalism of shape rules. Shape rules and grammars have been previously introduced into architectural design education to bolster the "shift away from individual design to languages of design" (Stiny, 1980).

Developing a design language is conditional for reflective practice as it allows designers to construct solid arguments and explicitly share their knowledge. Alternatively, a design language may be defined by shape rules in the context of visual computation. A broader understanding of computation acknowledges the role of process over product in contrast to the view of deeming computational design to technology, limited to the knowledge of making and the skill of using a hardware (Bermudez & Klinger, 2003).

Shape rules document the actions that make up the designs. The rule set, i.e. the grammar that defines the process up to a design, is an interpretative product and can be different each time it is created. A shape rule has a left side and a right side with an arrow in between. Each rule translates an action in the design where one shape (shown on the left) is changed into another (shown on the right). Thus, rules are the operators

in a computational representation of the visual and spatial transformations in design. Following, computational design is introduced as the means to accountability based on the potentials that explicitness of visual design computing hold.

2.4 Computation as the Means to Accountability

Knowledge, skills, and attitudes are a set of three variables on the effectiveness of university education achievements (Adam, 2006). The common objectives for specific academic units or curriculum are assertions of what a student is supposed to acquire, comprehend, and show as capabilities after training. For example, learning achievements for a novice architecture student will be determined by the student's proper understanding and capabilities in design.

Lately, computational design competencies have progressively been recognized in foundations studios, especially in outsourcing processes with (preferably visible) rules and digital media. However, while most institutions try to express their learned knowledge and abilities, they cannot explain how attitudes are anticipated because of the problems in measuring attitudes in short-term educational cycles.

In the relatively new higher educational track of computational architectural design, skills are generally addressed at the forefront, as expected in most higher education settings. The lack of acknowledgment of gained attitudes is especially the case for computational design education. Attitudes are almost indistinct. Computational design, mainly considered a technology, is often linked to intangible and hypothetical knowledge and abilities. Oxman (2017) recapitulates the theoretical studies on how these digital tools have shaped design thinking models from cognitive to computational to parametric design thinking. However, the inherent abstract knowledge of computational design absolves the learner from the social responsibilities of design thinking (Frampton, 2001; Fisher, 2012; Hadad, 2012).

Differently, this research argues that computing enables the designer to exteriorize designing and implant attitudes desirable in training a socially conscious designer. Research showing how attitudes are fostered in students is limited. Capabilities usually mean the ability to accomplish anything that is learned. The attitude or affect generally involves changing or developing ideals like sensitivity, moral conduct, or tolerance (Ewell, 2001). Not just the social sphere may give rise to certain ideals but also the

educational system. In this sense, Adam (2006) proposes that training outputs should not be taken into account as assertions only. They instead reflect a systematic framework for the development of curricula.

Simply put, it is not sufficient to accomplish some disciplinary skills. The learner should practice using those abilities both within and outside the discipline (Resnick, 1999) and with a larger perspective. The breadth here is constrained by accountability and collaborative activities advocated in architectural education as immediate outcomes of computational thinking.

Stiny has touched upon the relationship between visual rules and accountability and sharing. The explicitness of visual design computing facilitates the designer to partially exteriorize the design activity. In first-year studios, the externalization of visual design logic employing formalisms increases a learner's understanding of personal design learning and creates a foundation for discussing design as a computational process (Özkar, 2011). Designers use conscious thinking to develop relationships between parts to construct a whole. Instead of a discrete and one-time output, the design becomes a relational structure, allowing designers to create variants as needed.

On the other hand, appreciating the ambiguous quality of shape relations and their contribution to creativity, the abundance of meanings destabilizes the interpretation of actions. The articulation of design actions in a written format evolves into a strategy throughout the design process (Gürer et al., 2015). Similar studies (Gelmez & Bağlı, 2017) that propose writing as a way of reflection ask students to write down personal magazines for understanding students' awareness of their design learning. Externalizing one's internal process is integral to learning. It helps in comprehending the how of form-making.

Previous studies acknowledge the potential of formal descriptions, of sketches in their case (Prats et al., 2009), to externalize designers' cognitive processes. Using computational design and shape grammars in basic design education is established at architectural schools, and developments in approaches used have been widely reported. There here have been proposals in integrating rule-based approaches to design education in general (Knight, 1999; Economou, 2000; Li, 2001; Celani, 2002). They have also been introduced in first-year architectural design studios (Özkar, 2011; Gürsoy & Özkar, 2015) where they became visual representations of design moves

and served as means of reflection on action. There is still not much study on the attitudes that such instructional techniques encourage.

3. THE MULTIDIMENSIONAL CONSTRUCT OF ATTITUDES

How do attitudes contribute to learning? How do their meanings change in different domains? How can one assess attitudes to make them part of the instruction? This chapter first looks at the link between attitudes and learning in the context of higher education. The second part reviews relevant literature referring to attitudes both explicitly and implicitly. The last part of this section focuses on developed methods to assess attitudes. This chapter is designed to explain the arguments for the empirical work conducted.

3.1 Knowledge, Skills and Attitudes: Competence-Based Curriculum in Higher Education

Accountability surfaces as an explicit issue in university quality control processes. The answerability for performance is looked for at the institutional rank, granting universities considerable independence but still making them more accountable to the governments. Learning-outcome-based educational reforms are partially stimulated and promoted as a tool for curriculum development and curriculum coherence across the international standards of higher education. Simultaneously, learning outcomes are a governmental tool for setting up accountability-oriented educational systems concerning those outside the higher education area. A comparative analysis (Huisman & Currie, 2004) of the influence of accountability on European and U.S. higher education policy indicates that trends in quality assurance varied across nations, with the Netherlands building its quality control brand.

Further analysis of quality assurance and qualifications will follow in the next chapter. The learner-centered approach has been the norm for the European higher education area since Barr and Tagg's (1995) proposed paradigm shift for undergraduate education. In their seminal article referring to the American educational context, the authors state clearly that the objective of education is not to transfer knowledge to learners but to make them discover and construct knowledge for themselves through personal experiences. The Bologna process reforms done across the EHEA

emphasized the student as the center of the learning process (EUA, 2003; 2005; 2007; 2010; 2015). It entails a moving toward a notion of higher education that focuses on students rather than a teacher-led provision structure, shifting from a more input-driven curricular design to higher education centered on outcomes. (Attard, 2010). Consequently, evaluation of student performance is based, in contrast to input, on learning results.

Active learning characterizes learner-centeredness through a reflective approach to the process that translates to increased responsibility, accountability, and autonomy on the part of the student (European Commission 2017). The desired learning outcomes of a course or curriculum translate to competencies, namely the three European Qualification Framework (EQF) descriptors attitudes, knowledge, and skills. Attitudes, not always aligned with actions, are not directly observable in higher education (Kouwenhoven, 2009) and correspondingly in social psychology (Eagly & Chaiken, 1993). Nor are they as straightforwardly assessable through statements as other learning outcomes (Adam, 2006).

Attitudes, often domain-specific, extend to generic skills related to personal ethical qualities when transcending beyond the limits of the subject matter. Educational objectives are defined in terms of understanding, abilities, and attitudes that students will acquire because of their effective and active participation in a set of higher education experiences (Adam, 2006). Student-centered learning is an approach to curriculum development focusing on the learning process. Quality assurance is achieved through the assessment of standards based on the learning acquired (outcomes). Therefore, student-centered learning is an approach to curriculum development focusing on the educational activity where the student is the core of the learning process. The learner-centered model thus reflects the necessity of a focus on both learning and learners.

Many universities have sought to articulate the learning outcomes regarding the knowledge acquired and the skills developed. However, along with knowing (know-what) and abilities (know-how), an emphasis should be put on the motivation (know-why) to drive learners to care about mastering the new skill. *Motivation* is defined as the attitude and the confidence somebody brings to the competency (Castaldi & Tilney, 2003). It is the key ingredient to ensure that learning takes place. Similarly, (Norman & Spohrer, 1996) claim that students' engagement correlates well with learner-

centered approaches to education. It relies on the belief that when students are involved in a topic and eager to find new knowledge and abilities to address the problem at hand, they learn best.

While motivation has equal significance to other intellectual and practical skills and knowledge (Garner & Evans, 2015), it can be understood, shaped, and developed through learning experiences. Learner-centered educational settings encourage experiential learning. Accordingly, the student is the responsible person for constructing knowledge during the process of learning. In this study, knowing and learning are viewed as creative processes. Students learn better when they understand what they are supposed to be learning. Understanding is about asking questions about everything in one's experience that is experienced as questionable. Moreover, increased awareness of the values of actions is one of the components of accomplishment in ethics encompassing thinking and reflecting (Newton, 2001).

Three core processes should ideally work in a higher education setting: curriculum, learning, and assessment. While in almost every institution, grades are recognized as measures of students' learning, Hill & Barber (2014) call for an assessment renaissance that measures other attributes than knowledge qualitatively. In this sense, learning outcomes are crucial in articulating the objective of learning.

The assessment of student achievement is based on accomplished learning (outcomes) rather than on invested time and subject matter (inputs). Some of the benefits related to applying the learning outcomes in educational settings include centering the individual on learning, rewarding student performance beyond the curriculum, and increasing adaptability (Maher, 2004). The educational outcomes are the knowledge and skills acquired of a subject matter and not what students learn to do with the subject matter. Attitudes are a term recently referred to in higher education literature as a composing part of learning outcomes. This aspect represents the know-why kind of learning or attitude that are ethical conduct of an individual. Bringing attitudes to the forefront of the curriculum implies that the learners' achievement is articulated beyond the boundaries of subject knowledge, through transferable skills and personal ethical qualities. The norm is that tests and examinations fail to capture valued outcomes like higher-order cognitive processes and a variety of inter-and intra-personal competencies labeled as 21st-century skills.

A recent report on 21st-century learning (Bialik et al., 2016) points to three more learning dimensions other than knowledge, which assessments need to measure: skills, character and metacognition. The fourth dimension amplifies all by making students reflect and progress the other three categories, strengthening their convictions and attitudes regarding their learning abilities and cope with their learning difficulties. The most important reason for developing metacognition is improving cognitive and non-cognitive attributes in realms beyond the primary learning contexts.

Knowing, being able to do, and doing it are a dynamic combination of competencies to be achieved by the student. The origins of learning outputs in higher education are hard to trace. They became consolidated when used as standardization measures within the Bologna Framework. In order to conform to the European Higher Education Qualifications Framework (FQ-EHEA), numerous competence programs have since been established.

A notable exception from a European perspective (Bergan, 2007) argues that a consideration of approaches to learning cannot be divorced from considering the reasons for learning. How and what one learns has to do with why one learns. Bergan claims that personal development has been ignored in the Bologna discussions while it is essential at the individual level among the four primary purposes of education.

There is confusion in the Bologna lexicon. There is no specific agreement about the term learning outcome. Learning outcomes are used interchangeably with competencies, and sometimes competencies are referred to as skills. They have in common that both are addressed in terms of understanding, abilities, and dispositions. While learning outcomes are supposed to be what the learner will know in the conclusion of the course, competence is the capacity to choose and apply the characteristics required for a specified degree of performance (Kouwenhoven, 2009). Even the use of the term competencies is disputable. The various definitions of learning outcomes are ground on the same core elements: knowing, understanding, and doing (Bergan, 2007).

In a different light, educational objectives are a conceptual framework for curriculum organization (Adam, 2006). The learning outcomes shape the focus of instruction that is followed in a course or program, and vary depending on the perspective of the

educational committee, the lecturers, the learning situation, and the competencies obtained by the students.

It is intricate to make a clear distinction between knowledge, skills, and competence since they are not mutually exclusive. Referring to competence as a category on its own, implying responsibility and autonomy instead of attitudes, is also questionable (Karseth, 2008). Despite their importance within the Bologna educational reforms, there is a pure level of understanding and a rare practical implementation.

Based on five general capabilities, the present Bologna Framework is based on Dublin descriptors: knowing and comprehension, awareness and understanding, making assessments, interaction, and continuous learning. A different overarching framework, the European Qualifications Framework for Lifelong Learning (EQF), focuses on lifelong learning and encompasses all education levels (European Commission, 2008). Significant lifelong learning abilities are those that all people require for their satisfaction, civic engagement, solidarity, and employment in the knowledge-based society. The following Tuning Project descriptors (González & Wagenaar, 2008) operate at the levels of the disciplines, i.e., subject-specific competencies.

A diverse outcome-oriented framework, ACQA (Academic Competences and Quality Assurance) endorses design as a new competence. The conceptual framework is co-developed by TU Delft, TU/e, and the University of Twente (Meijers et al., 2005). It includes seven skill sets and a level descriptor of the analytical, synthesizing, conceptual, and materialization tasks. As a result, seven areas of aptitude that differentiate a university graduate may be identified, and designing is one of them. Many degree holders will design while undertaking research. Design is an artificial process that generates ideal standards by realizing new or improved artifacts or systems in line with specified criteria and objectives.

Research on attitudes in higher education falls into three groups. The studies that measure student attitudes towards certain subjects treat attitudes as opinions and beliefs towards an attitude object. Other studies explicitly refer to attitudes as a term or implied under other terms like dispositions, attributes, competence, habits of mind, habitudes, and habitus.

There is research on learning dispositions that focus on the dispositions necessary for successful learning. Katz & Raths (1985) define dispositions as mindsets, inclinations

to respond in some ways to events. According to Perkins, a disposition includes three components: aptitude, tendency, and awareness of situations. Being willing to act in some way is having the competence to do so and being conscious when necessary.

It is possible to acquire knowledge and develop skills without having the disposition to use them. Attitudes in this case, enable the awareness of making use of the understanding and abilities, in relevant situations. Some of the learning dispositions are curiosity, friendliness, resilience, playfulness, and reciprocity (Carr & Claxton, 2002), yet the list is not exclusive. Some (Lave & Wenger, 2016) argue that these personal traits are situation-specific, and it is challenging to talk about enduring dispositions. The common belief is that there are no didactic processes to address attitudes.

Although knowledge and skills are regarded as cognitive learning outcomes, the non-cognitive growth of learners concerns the improvement of attitudes, values, and character in general (Nusche, 2008). These values and attitudes encompass societal duty, moral sensitiveness, resilience, and many more. The list is not at all exhaustive. The extent to which higher education helps to advance these non-cognitive skills is also disputed.

Personal competencies are integrated performance-driven attributes consisting of understanding, abilities, ideals, and dispositions. Knowledge, skills, and attitudes are utilized in integrated way but varying degrees depending on the occupational task. Self-concepts and values cannot be immediately observed but are part of the elements which influence professional conduct, different from skills and knowledge that are discussable and perceptible. So, like knowledge and skills, attitudes are a cognitive attribute defined as the mind's willingness to perform or respond in some way (Main, 2004). The question is how to make attitudes tangible and discussable? Drawing the discussion to the design education context, how do attitudes contribute to design?

Attitudes come under other terms in the higher education literature. Learning outcomes shape the focus of instruction followed in a course or program. The relation between learning outcomes and assessment is confusing and complicated in practice. Ideally, all learning outcomes should be assessable. Three core processes should work in a higher education setting: curriculum, learning, and assessment. Grades are often the measures of students' learning (Hill & Barber, 2014) call for an assessment

renaissance that measures attributes other than knowledge in a qualitative manner. Learning outcomes, in this respect, are crucial in the articulation of the purpose of learning.

Competencies should be assessable and continuously evaluated for relevance and impact. While discipline-specific competencies are less disputed, identifying the most important and desired transferable competencies has proven difficult. This issue is particularly apparent regarding civic engagement and diversification skills as there is no widely recognized concept of what these competencies are or entail (Bergan & Damian, 2010).

Students reflect at different moments during curricular learning. In these reflecting moments, the unifying feature is that reflections assist students in comprehending and improve their learning experiences. Students add meaning to what they do during reflection or express the meanings of action or experience in the study process. Further, students record valuable learning moments by reflecting in action when conducting a creative task. They examine what they have accomplished or connect new information to past knowledge in the process of designing. Students consider what abilities or know-how they need to achieve high-quality deliverables.

They write these comments periodically in a learning journal (Moon, 2004) by showing their results and processes. They also reflect upon and for action at the competition of the curriculum. They reflect on what they have accomplished in the learning activity and how this has contributed to developing skills. They recollect what they have accomplished and helped build competencies in the learning activity.

The concept of competence is an individual's capacity in a particular professional, social, or learning setting to learn, choose and utilize the information, skills, and attitudes necessary for efficient conduct. The significance of knowledge acquisition is not a purpose but a way of developing the skills required to fulfill a specific activity or role. In other words, knowledge and understanding are not anymore the foundation of a pedagogical approach based on competencies. Students learn lived experiences by carrying out genuine learning activities to discover the know-what/ how and why of learning. The "how" relates to skills to be acquired and the "why" to the purpose of all the learning activities. In design education, for instance, they contribute to the entire

design competency of students, shape their design approach, development as designers, and their learning capacity.

Surprisingly, an attitude may exist on two distinct levels. Explicit attitudes are those that exist at the cognizant rank, are purposely constructed, and are reportable. On the other hand, implicit attitudes are intuitive attitudes developed involuntarily and are generally unknown to the individual. Attitudes gained during the learning process are of the explicit kind. Self-reporting and observation are the two most frequent approaches for determining explicit attitudes since they are known to the individual and observable by an outsider. While they are frequently used interchangeably, the terms skill and competence have different meanings. The term skill refers to the methods or instruments used in a context and their application to specific activities. *Competence* is a comprehensive word that stands for the learner's capacity to handle new situations and unexpected problems by using and applying knowledge and skills independently and self-directedly.

As there is an increased interest in design attitude, the foundation design studio will serve as a context to examine the relationship between attitudes and learning. Basic design, a format for foundations studios, is a suitable medium for learner-centered approaches. The student becomes the central learning actor through a hands-on engagement to develop individual skills and build personal experiences.

Buchanan (2008) assumes that design is the contemporary culture as it combines knowledge from several fields and is helpful to individuals outside of the professional design practice. The idea is to lead the students to know how to act even beyond their professional competence. Therefore, there is a shift of focus from know-what (knowledge) and know-how (skills) to know-why (attitude).

Character development and learning are intimately related. Buchanan (2001) brings to the attention George Nelson's view of the generalist character of the designer. Interestingly, one of the educational objectives stated in the UIA/UNESCO Charter for Architectural Education "is to develop the architect as a generalist." The issue of the designer's generalist versus expert personality is one of perception rather than expertise. The perspective consists in making use of the specialized knowledge even outside the profession's domain. Discussing character formation and all its related

aspects is out of the scope of this research. The reason of bringing it up is that the study considers attitude formation as part of the character development.

Significantly, in 1928, at the Bauhaus, Moholy-Nagy had already thought of extending design education to all professional schools, as he treated design as a way of thinking rather than a vocation. For him, design is thinking in relationships. Moholy-Nagy's concern was to devise a pedagogical method for the new society that would encourage a sense of responsibility within students. He emphasized a process-oriented training that would lead to the learners' inner change or conversion. He proposed an approach, which clearly states the relationship between the roles of the design attitude in character formation through active learning. Similarly, Simon (1996) argued that all practice-based professions are fundamentally related to designerly ways of conception. He held design as a decision-making activity and adopted it in the management field.

Today, large organizations are actively promoting design as an integral part of their culture. Some studies attempt to examine the design culture qualitatively through values and attitudes (Michlewski, 2008). A greater emphasis on the concrete qualities of design culture will benefit all types of education, whether in schools of management or schools of design, or the many other disciplines.

While the desired result is to achieve student learning, it is not well defined how it applies in different areas of teaching and learning. Hence the thesis aims to discuss the learning paradigm in practice within the design education context first. The basic design education is a suitable model for the learner-centered approach through active learning and experience-based pedagogy. The emphasis will be on the relationship that is assumed to exist between attitude, apart from knowledge and skills, as a critical element to the learning process that leads to inner transformation.

Though not explicitly mentioned among the 21st-century competencies, attitudes are traced among the socio-cultural, cognitive, and metacognitive dimensions of learning. They stand for collaborative learning, applying critical and creative thinking in real-world contexts, and learning through self-assessment, reflection, and self-regulatory practices, respectively.

As it requires complex problem solving and reflection, presenting students with design challenges are unique to developing 21st-century learning (Lawson, 1991; Schön, 1983). Design issues are ill-defined and are frequently referred to as wicked problems

because of uncertain objective definition, no predetermined solution route, and the requirement to merge multiple knowledge areas (Jonassen, 2000). Students must participate in creative and critical thinking, gather, edit, and prototype ideas, monitor progress, and manage team relations to tackle such challenges. As a result, the relevance of design challenges is crucial for contemporary skill acquisition. It can also help learners cultivate effective personality traits like endurance and resiliency during the process of bouncing back from difficult experiences.

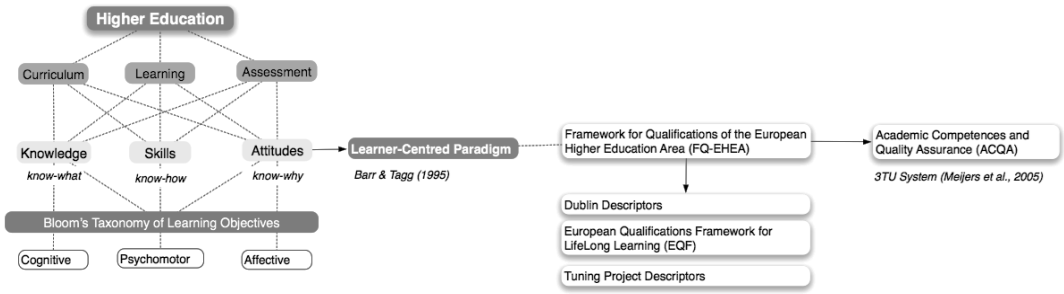


Figure 3.1 : The attitude construct in various curricular frameworks.

3.1.1 Learning outcomes considering epistemological perspectives

Foundations for learner-centered education hark back to Socrates, who was the first to emphasize the learner, followed by Locke, who introduced experiential learning. Later educators like Pestalozzi, Herbart, and Froebel designed and popularized learner-centered curricula. The sociologist Lev Vygotsky, the psychologist Jean Piaget, and the philosopher John Dewey shaped the learner-centered paradigm into a program called constructivism.

Foundation design studios offer a proper setting to increase the sensitivity of student designers to the ethical dimension of their practices by a situational "learning by doing" approach. The learner-centeredness instruction followed in this studio is based on the instructor's model as a negotiator: someone who acts as a catalyst and guide for the student's learning process. Design education should be oriented to fostering independent judgment apart from the acquisition of fundamental skills. Only informing, without forming, students to know how to do something will not contribute to the knowledge production. In this study, knowing and learning are viewed as creative processes.

Dewey emphasized knowledge as a statement of action and developed his notion of occupations as an instrument for learning by action (DeFalco, 2010). Similarly, the

basic design approach in foundation studios is not intended as a prototype to professional design (Gürsoy & Özkar, 2015) but as an instrument of learning. In a way, the contextual thought experiments that arise from the basic design educational context respond to the critiques directed towards minimal guidance during instruction models of learning (Kirschner, Sweller, & Clark, 2006). Accordingly, if the instructional content of the learning experience is like the techniques and processes (i.e., the epistemology) of the field being studied may be a fundamental mistake. Hence, pedagogy, the way one learns in an area, is not equivalent to epistemology, the way an expert works in his field. Therefore, in foundation design studios, basic design instruction can serve as an instrument for learning by action.

3.1.2 The social and reflective learning theories

Collaborative learning is an attitude and a mode of communication based on constructivist and social learning theories (Bandura 1977). In his thesis on social Constructivism, Vygotsky (1978) suggested that learning is fundamentally cooperative and cannot be isolated learning from its social setting. Externalizing the design knowledge to reflect on the activity falls in the theoretical framework of constructionism of Papert, building upon Piaget's and Vygotsky's work. Adding the social aspect to constructivism entails students constructing their reality in a social environment, together with other peers. Constructivism relies on external and typical constructions of the subject, whereas Constructivism highlights the individual as the maker of experience. It requires creating an output to share with members of a society (externalizing) to get input, allowing for rethinking (internalizing) and creating a new concept (externalizing) as a result of the sharing (Papert, 1990). The whole process of internalizing and externalizing becomes crucial to an individual's growth.

For instance, the design student's learning episodes are formed by panel reviews, individual critiques, group projects, and any mode of communication in the studio context. According to the constructionist approach, these architectural students would be active contributors instead of passive consumers of information. Differently, constructivists would be regarded as particularly creating their understanding and knowing within a context characterized by the physical and social features of that specific context. Finally, architecture students would be active knowledge creators, able to communicate their knowledge by externalizing (generating and talking about

it) and internalizing (receiving criticism and reflecting on their knowing), and then externalizing again. Active knowledge-building and contextual interaction occur in design studios; hence the social constructivist viewpoint this study takes.

3.2 Attitudes from a Social Psychology Perspective

Although attitudes as learning outcomes are often muffled, they are among the essential constructs in social psychology (Allport, 1935; Eagly & Chaiken, 1993). Attitudes refer to the orientation of an individual, grounded on experience or pragmatic learning, and expressed toward any abstract or concrete concept or situation. When employed in the social and behavioral sciences, attitudes, values, beliefs, prejudices, and opinions are open to differing interpretations, overlapping connotations, and even interchangeability. Attitudes are multidimensional psychological dispositions. When deduced from observable behavior, attitudes are an inclination to act in particular ways towards people and situations. The degree of like or dislike displayed indicates a positive or negative attitude. In that respect, they are evaluated as a hypothetical construct. Combining multiple viewpoints, Rokeach (1976) describes attitudes as a reasonably durable structure of ideas about an item or circumstance which predisposes one to behave preferentially.

Attitudes are evaluative (Thurstone, 1928). They cover our likes and dislikes about everything (Zanna & Rempel, 1988). They are a learned predisposition (Ajzen & Fishbein, 1980) or an inclination manifested by assessing a being with a certain level of favoring or disfavoring (Eagly & Chaiken, 1993). Often, they are predictors of people's actions, considered as "pre-computed evaluations" (Olson & Kendrick, 2014). Attitudes, layered as affective, cognitive, and behavioral, correlate to one's assessments of, knowledge about, and tendency to behave toward the target of the attitude (Wagner, 1969). The tripartite model of attitudes stands for the aspects that engage in forming and expressing attitudes. They enable individuals to respond promptly or adapt to changing contexts and hence are referred to as active "habits of mind" rather than mindless habits (Katz & Raths, 1985), manifested through actions of consequent reflection. It is different from mindless habits, allowing people to respond promptly and even adapt to changing contexts. Cognition plays an integral part in distinguishing between implicit and explicit attitudes. While the former is

automatically activated, the latter requires motivation and a cognitive effort to be retrieved from memory (knowledge) (Ajzen & Fishbein, 2005).

There are comprehensive reviews (Crano & Prislin, 2006; Bohner & Dickel, 2011; Albarracin & Shavitt, 2018) covering the research of the last two decades on how attitudes form and change. Research shows that a different mode of thinking, metacognition, is crucial in changing one's attitude. Metacognition is the knowledge and reflection of people about their cognitive processes or others (Jost et al., 1998). Thinking about thinking (Flavell et al., 1993) is an essential process for learning in general, involving reflection and action (Millis, 2016).

A common issue in attitude assessment is that attitudes are not directly observable. In that respect, LaPiere's seminal work "Attitudes vs. Actions" (1934) demonstrated that attitudes and actions do not always align. The attitudes shaped by social media are an actual example. Knowing being followed, people may act differently from their beliefs.

Attitudes are a predisposition to act; Attitudes are learned; Attitudes may change over time; Attitudes are composed of affect, cognition, and behavioral components; The social context shapes attitudes; Attitudes vary from short-term to enduring; Attitudes are implicit (not having conscious access) or explicit (one has conscious access and is engaged more deliberately); implicit attitudes are automatically activated differently from the explicit ones that need effort and motivation to be recalled from consciousness; Attitudes are not directly observable.

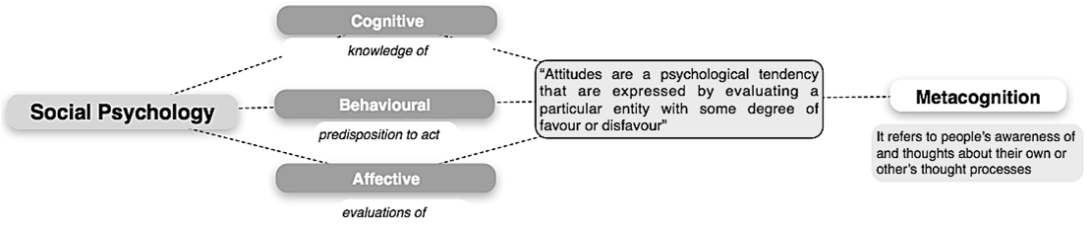


Figure 3.2 : The attitude construct in social psychology.

3.3 Attitudes from a Design Thinking Perspective

Recently, attitudes have been at the center of research since design thinking was introduced into organizational management. There are ample studies on design and its role in social innovation, notoriously represented by design consultancies (Brown, 2009) or academics promoting design thinking to the business communities (Martin,

2009). In contrast to the decision-making attitudes of managers (selecting among alternatives), design attitudes espouse while problem-solving by applying abductive reasoning. The attitude construct here stands for a mind-set which first takes a divergent view by creating choices, and second, it converges towards a reasonable choice.

Rather than advocating design as a set of five to seven steps that anyone may follow for achieving innovation and competitive advantage, other research claims that the values and attitudes that professional designers hold (Michlewski, 2008) make them an added value for the organizations. Labeled as design attitude (Boland & Collopy, 2004), it refers to the beliefs, aspirations, and the adjustment that a designer brings to an organization, highlighting the designer's capabilities as a distinct set of heuristics that deviates from the decision-making attitude of managers.

It is a holistic concept referring to the abilities, capabilities, and dispositions of professional designers and organizational learning. The authors claim that adopting a design attitude will assist future managers in thinking of themselves as designers "who contribute to human betterment," with a commitment to openness. The origins of a design attitude in management thinking may be traced back to Simon (1996), who proposed a new management curriculum based on design or the organization of human actions. Considering managers as form-givers who shape organizations, their professional responsibility is to act responsibly, just like designers. These arguments ground on the research on implications of design thinking into occupational and organizational cultures.

A crucial theoretical influence on the attitude construct for Bolland and Collopy has been the work of the French sociologist Pierre Bourdieu. Accordingly, individuals own a habitus standing for the structures of perception, conception, and action (Bourdieu, 1977). To oppose the determinism indicated by theoretical models of society, with the structure having precedence over the agency, the cultural theorists claimed a need for a more comprehensive understanding of the agent and his actions in the environment.

Two issues bear explaining the design disciplines: first, the whole design attitude discussion is credited to the designer's creativity. There is a persistent emphasis on the individual designer's thinking (Cross & Cross, 1995). Second, designing is more than an isolated cognitive process, as the design practice is informed by the situated social

context that designers operate. In this respect, there is little on the social aspect of the designing process.

One exception is the recent design on innovation literature which focuses on the design attributes deriving from the professional design culture as displayed in organizational settings (Michlewski, 2008). This view follows Buchanan's (1992) introduction of the role of designers as reflective thinkers to the organizational fields, expanding design attitude to the human aspects of designing.

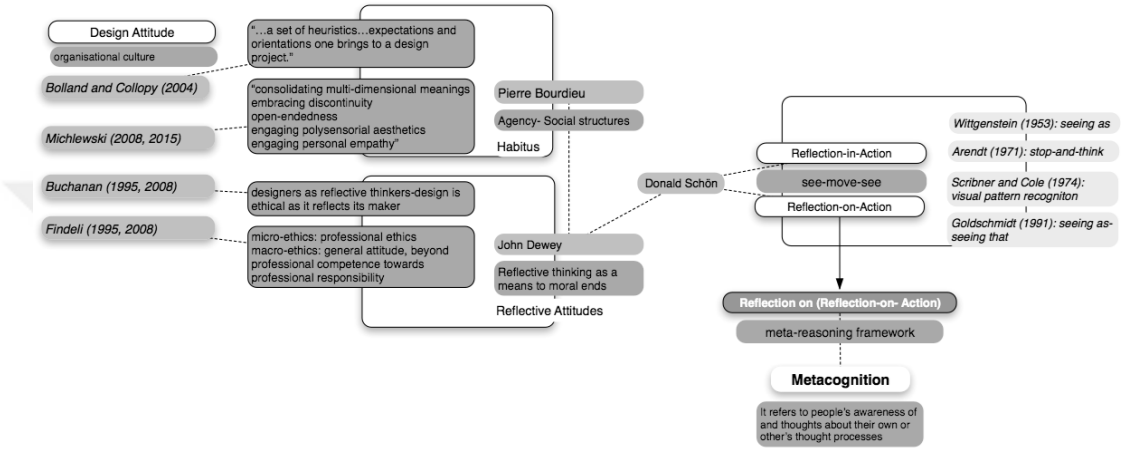


Figure 4.1 : The attitude construct from a design thinking perspective.

The study extended the notion by empirically exploring what makes design attitudes exhibited by professional designers in organizations and its implications. It identified several shared values among designers that characterize design attitude. Those values are embracing uncertainty and open-endedness (willing to take risks), engaging a deep empathy, appreciating the power of all the five senses, creating by materializing concepts and tactics, and owning the motivation to employ and integrate many views as designers tackle complicated challenges. Such studies offer insight into the way designers think and act while collaborating across disciplines. Collaborating attitudes stand for the ability to listen, understand one's reasoning process and embrace the views of others, beyond working only with someone who thinks alike.

The design attitude literature refers to designers as cultural agents who interpret those values in context. As this scholarship deals with professional designers who reflect an inherent attitude, this research raises some questions. While designers might have an intuitive understanding of social and ethical values and attitudes, a difference exists between design attitudes, a collection of heuristics, and attitudes for design which vary depending on the diverse forms of design practice.

Here I refer to the four design domains proposed by Buchanan (1992), encompassing the design of communication, material things, services, and systems. In this context, professional designers feature prominently, less as form creators and more as cultural mediators (Julier, 2007). Some designers have long believed that design plays critical social, political, and economic functions, with examples extending to the beginning of the 20th century.

Despite the expanded forms of the design domain, form-giving and making are still central to design practice. The concept of form that has grown more flexible and complex, embracing the social and environmental context of design. Özkar & Steinø (2012) relate attitude formation to knowledge and skills through the form. Form is framed as the means of teaching something operational that involves doing and thinking simultaneously. It supports viewing design education as a venue for teaching design attitudes with awareness of the designer's responsibility for good organization and decision-making (Buchanan, 2008).

4. A STUDY ON REFLECTION AND ATTITUDES IN A FOUNDATIONS DESIGN STUDIO

Within the scope of the thesis, a study was conducted in a foundation design studio. The objective is to demonstrate that computational reasoning contributes to the acquisition of good attributes in design learning. The claim is founded on the framework introduced so far to support the argument that computing allows for the outward manifestations of reasoning, sharing, and accountability. The purpose is to incorporate computational thinking since the beginning of design education and essential skills and knowledge. Understanding the relation system that underlies a design via visual rules contributes to thinking, decisions, and judgment. The rules are instruments to determine the relations between shapes promoting reflection for attitude formation.

The study shows that computation in early-design education instills reflective attitudes by encouraging learners' knowledge sharing with consequent accountability. Computational formalisms are visual computation instruments that enable designers to materialize and reflect mutually on design ideas. A growing number of first-year architectural design studios across the world incorporate computational design skills. These mainly involve using digital tools and occasionally the additional externalization of processes with (ideally visual) computation rules.

Shape rules are visual computation formalisms and generative to the design process (Stiny, 2006). They are operators that inform a computational process in terms of visual and spatial transformations/combinations of two and three-dimensional shapes. Even if students do not always adhere to shape rule's formalism, a left side and a right side with an arrow in between, they are aware of shapes that come before and after. Identifying a series of spatial relations and corresponding rules becomes instrumental for the external interpretation of actions. While documenting thought processes, computational formalisms like shape rules, support beginning designers in developing attitudes of accountability for their design thinking as necessary for critical reflection.

The argument is developed and illustrated in a tri-partite method with reference to the three interrelated forms of accountability as defined in Chapter 2. Reflection in a collaborative setting surface as two persistent conditions for implanting attitudes of accountability among learners, across the three design studies to follow. The issue of accountability is addressed in three instances: a. being accountable through a shared design language in the collective act of learning and designing, b. being accountable through form and form relations, and c. the impact of process sharing on accountability.

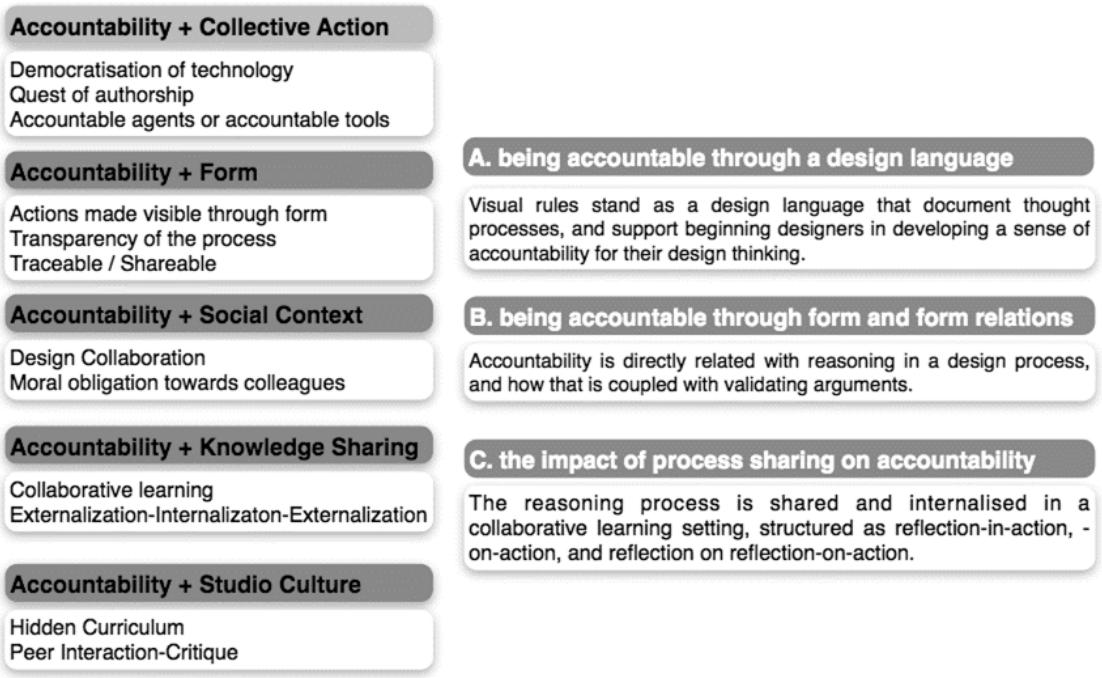


Figure 4.1: The tri-partite method developed with reference to the interrelated forms of accountability.

In the first study, visual rules stand as a design language which document thought processes, and support beginning designers in developing a sense of accountability for their design thinking. Visual rules are conceived as the devices of design technology which enable reflection upon collective technological actions.

In the next design study, the reasoning process is shared and internalized in a collaborative learning setting, structured as reflection-in-action, reflection-on-action, and reflection on reflection-on-action. Last, evidence for accountability is sought through an analysis of students' attitudes and how they appraise the processes in their reflections, by employing the linguistic analysis technique.

In the third study, accountability is related with reasoning in a design process, and how that is coupled with validating arguments. This approach is exemplified with reference to the Socratic dialogue, *Meno*. Drawing parallels to the visual reasoning in the dialogue, students enact a version of the dialogue by producing multiple instances of the same relation, helping them comprehend the concept of thinking in relationships.

4.1 The Formalist Language of a Foundation Design Studio

In architecture schools, basic design is a pedagogical model for foundation studios. The studio format is frequently regarded as the best setting for a learner-centered strategy. It is debatable whether every contemporary interpretation of the basic design course fits the same model or not. The essence is in the attitudes and dialogues enabled for students to reflect on their own and develop their position in action. Recent research supports the idea that learning is holistic and integrated across cognition, perception, context, and ontological development (Williams et al., 2015). Active or hands-on learning is an approach to experiential education. Dewey (1933) would define it as the experience that involves the interaction between objective and internal conditions. The instructor's activities and the materials with which the student engages are the objective conditions. Personal requirements, attitudes, capacities, and purposes are examples of a learner's internal conditions.

The idea of hands-on learning is at the core of the works of kindergarten educators like Pestalozzi, Froebel, and Montessori. The aim behind this pedagogy was to develop a feeling of personality in the child through perception. Similar education theories and philosophies with a focus on the sensorial experience prevail the basic design pedagogy. Sensory experiences are crucial for the development of the individual thinker. Similarly, Saranlı (1998) associates basic design with the character development of the learner and considers the foundation course as a process of personal discovery.

The students are encouraged to reflect on their reasoning concerning the decision-making context. The reasoning process dwells on a formal vocabulary for purpose of facilitation. The student deals with abstract compositions to relate shapes partially and in a unified-whole design. Although basic design pedagogy is criticized as a formalist approach to architectural design, the aim is not to make students acquire a style. The abstract forms are tools to facilitate the reasoning process while designing.

Abstraction here serves as a method of intellectual inquiry into the design. Abstract forms are a temporary tool to facilitate the process of judgment, by keeping the focus, not on form as an entity but relations. Knowing how to deal with abstract forms and form relations is valuable to attitude formation. They help the individual develop an awareness of questioning the tools at hand (Özkar, 2005) and develop personalized knowledge of general form relations that could be applied, as the organizational capacity of form in different contexts.

Abstract forms and form relations are the pedagogical tools of personal development. Abstraction facilitates thinking and the collective discussion of the design process while being involved in the activity fosters collaborative skills. The learner-centered approach aligns with the hands-on practices where the individual builds up knowledge and develops skills in a personal process. It requires individual engagement in the activity by sharing personal learning processes.

The potential of abstract forms to encourage reasoning while learning is acknowledged in the Socratic discourse of Meno by Plato. While the pedagogical values inherent in the dialogue deserve special attention and discussion, this part supports the argument. The Meno dialogue constructs upon actions, which evolve in a step-by-step process. As the main theme of the dialogue is "learning as recollection," a similar-to-computation process is employed to facilitate reasoning towards an increased understanding.

The pedagogy for transmitting the rule-based approach to students requires learning by doing and the involvement of the students in the process. The individual thought process starts with how the student sees abstracts shapes as isolated from the material world. As shapes are abstract and non-representational, they offer multiple opportunities for interpretation. The abstraction process relies on how the shapes are perceived visually. The student starts to develop visual rules at the beginning of the process of shape abstraction. Shapes and visual rules interrelate with each other. In the first instance, shapes give way to rules, and in the second instance, rules give way to the emergence of shapes. For Kandinsky (1947), the dialogues emerging between shapes and visual rules are the tools to "develop attitudes."

Rules allow the students to make explicit their design reasoning, and in consequence, they develop awareness about settling new relationships between forms. Reflecting

continuously on their design processes enables the students to grow good habits and understanding to be applied in other contexts. Foundation design studios are a potential setting for design and ethical reasoning to be learned simultaneously. This argument is grounded on several points of view. According to the learner-centered approach followed in design studios, the instructor is no longer the authority figure who devises action rules. The students become responsible for their learning process through self-reflection and interpretation. As the design is acknowledged to be a reflective practice (Schön, 1983), previous studies suggest using visual rules as tools for self-reflection during the design processes (Stiny, 2006; Özkar, 2011).

In the following studies, the formalism of shape rules is introduced to a group of first-year architecture students in Epoka University to explore through protocol study whether students could utilize them not only as means of reflection but also of conversation and collaboration in a tacit process of acquiring attitudes of accountability towards peers.

4.2 Reflecting and Accounting with a Shared Design Language

The study is conducted with first-year architecture students in a foundation studio course at Epoka University. The pedagogy of the first-year architectural design studio in this university relies on abstraction as an intellectual and practical method of inquiry into design. In many foundation studios, abstract forms are tools to facilitate the judgment process by keeping the focus not on form itself but on exploring the relations between forms with minimal number of features. Comparisons of form entail paying close attention to features, and particular shape attributes to draw out relationships. Defining form relations consists in perceiving parts and wholes visually and relating those various forms at different levels of complexity. Attitude formation can be related to knowledge and skills through form, where form serves to teach something operational that involves doing and thinking simultaneously.

Designs can often be articulated concerning the spatial relationships that exist within them. Rules represent the visual or spatial relations in a design. Stiny (1980) proposed an original rule-based design approach to the intuitive methods of defining relations. While the rule-based designs are associated with parametric design, they are at root non-digital, as rules are developed based on visual and perceptual properties of shapes.

The rule-based approach helps students "shift away from individual design to languages of design" (Stiny, 1980), becoming helpful in outward manifestations of acts in collaborative practices. What follows are three illustrated examples in support of the argument. The tasks assigned to students are abstract thematic compositions with two-dimensional or three-dimensional design elements. The design language's spatial relations are developed by considering the parametric, geometrical, physical, and even material attributes of two or three-dimensional shapes.

Towards the end of the Fall term of 2016, students are asked to organize a certain number of points and planes on a given grid as part of their final assignment. In a later step, the points and lines are converted to linear and planar elements respectively to achieve a three-dimensional organization. Students are encouraged to develop their design languages by defining rules of relationships between their proposed shapes, as in Figure 4.2. The documented shape relations are integrated into the design process while being open source for every other peer to learn. The documentation is done by orthographic hand drawings representing the spatial relations of shapes regarding the assigned grid.

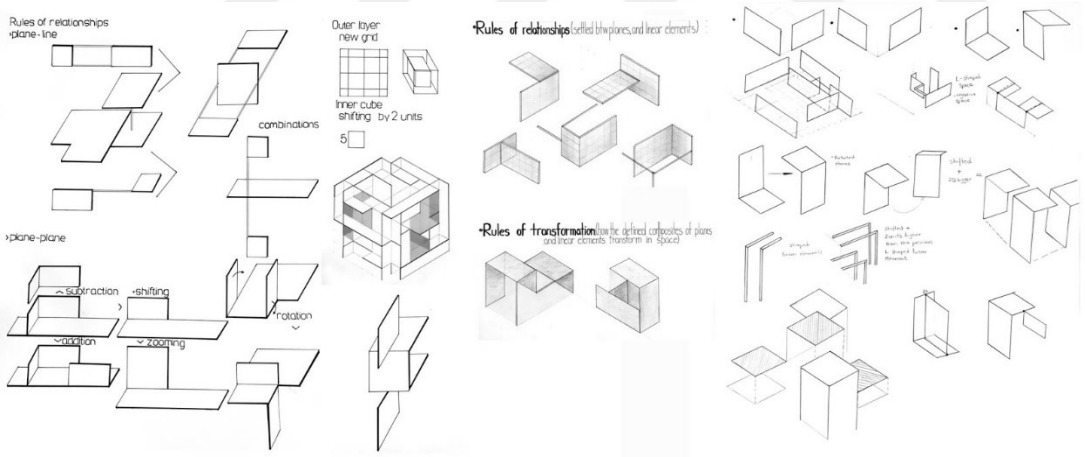


Figure 4.2: Design languages showing possible spatial relations of elements, as proposed by different novice students (Fall 2016).

In the illustrated examples, the participating student group did not always follow technical precision when defining the shape rules. Nonetheless, they were able to represent the actions that transform one shape into another in their designs. Figure 4.2 shows what three students out of the group represented when they were asked to show the spatial relations they designate while designing with given design elements as shape rules. Students systematically visualized different combinations of the spatial groupings of the planar and linear design elements they used. By thinking on isolated

relationships expressed with visual rules, students had the opportunity to reflect on the constructive basis of their designs. They develop their categorization of rules which are mainly rules of relationships and rules of transformation. In the leftmost example of Figure 4.2, Student 1 defines rules between plane-plane and line-plane, which are then combined. She accompanies her actions with wordings like shifting, rotation, subtraction, and addition. Similarly, in the central example, Student 2 explores different combinations between the same elements, two planes, by shifting one concerning the other. Next, she illustrates how the defined composites of planes and linear elements transform in space. In the last example, Student 3 explores the variation of how two or combinations of planes define space by altering the proximity between the planes and their orientations concerning the assigned grid. These drawings became instrumental in externalizing their decisions, design languages and further actions.

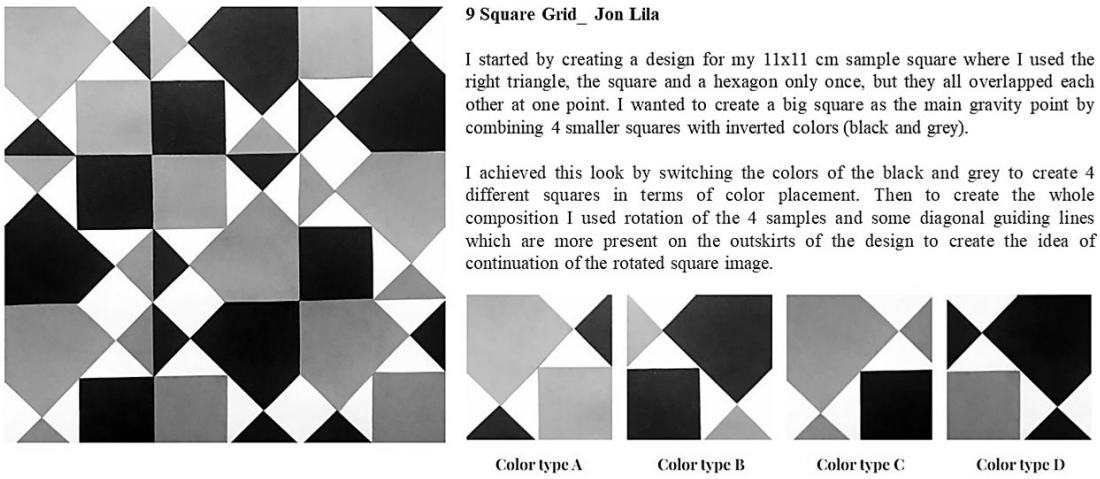


Figure 4.3: Student work and the language of design as proposed for the nine-square grid exercise (Fall 2020).

Students were asked to explore possible shape relations within a square unit area in a different design exercise and try out multiple options. Later, students would organize nine of these units in a whole unified composition to form a larger square, as exemplified in Figure 4.3. Disregarding the pedagogical objectives of the nine-square grid exercise, the focus here is on how the student develops a design language based on the tones or weights attributed to shapes. The student assigns tones interchangeably to achieve different configurations when the units are combined. Hence, the shape weights are another design input that enables students to develop their design language.

Students were asked to make a solid-void three-dimensional design by assembling incrementally solid elements in a subsequent exercise. As a preliminary step, students would develop a vocabulary of their own through rules that articulate their design approaches in relating the design elements. Students were expected to develop design languages by developing rules of relationships settled between at least three solids and rules of transformation on how the defined combinations transform in space by rotating or shifting regarding the X-Y-Z axis. This exercise is exemplified in Figure 4.4.

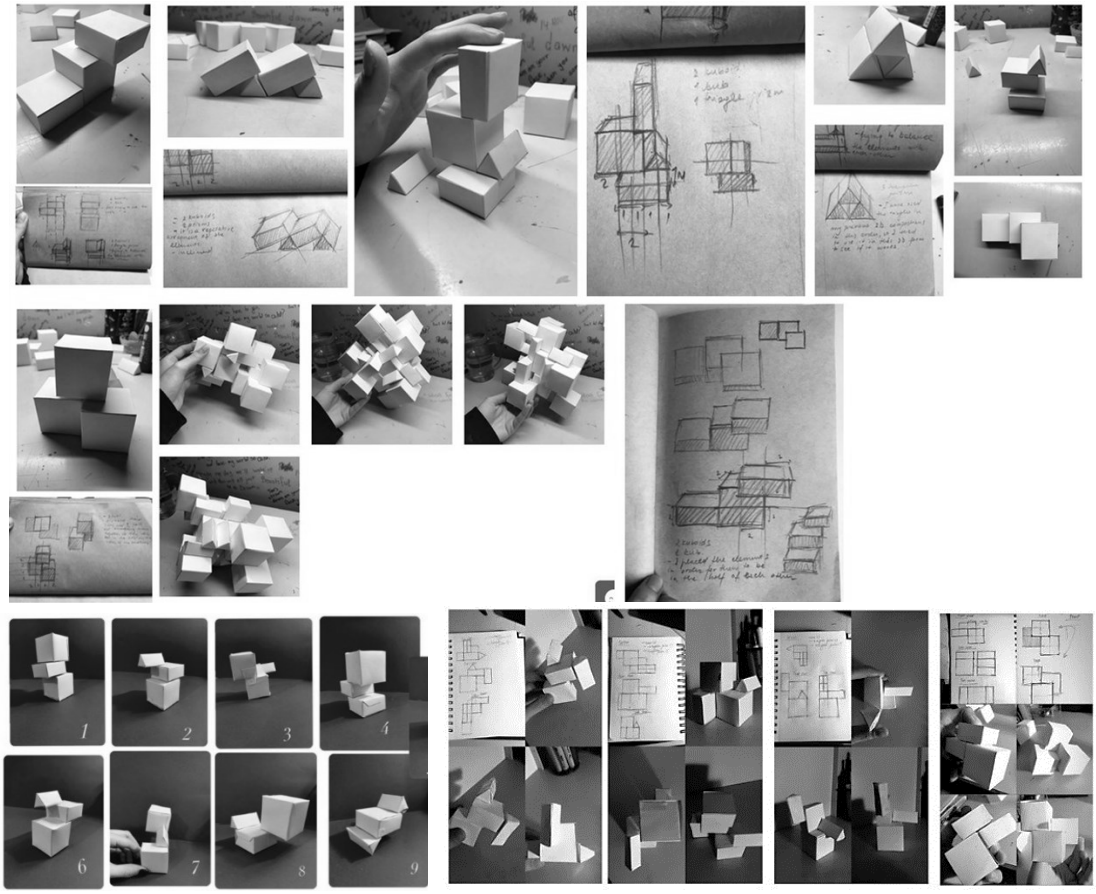


Figure 4.4: Explorations of developing vocabulary of three-dimensional shape combinations and organizations (Fall 2020).

By thinking about isolated relationships as expressed with visual rules, learners can reflect on the constructive basis of their designs. They do not necessarily employ every combination in their final designs. The aim is to encourage students to reflect through visual rules and thus develop an explicit awareness of their designs. This understanding allows the learner to make use of personal experiences in subsequent moves and situations.

4.3 Impact of Process Sharing on Attitudes in a Foundation Studio

This part presents the method of a design study organized in a beginning design studio. Conducted as a two-tier method, as illustrated in Table 4.1, the first part dwells on reflection conducted in a collaborative setting as two conditions for implanting attitudes of accountability among learners. The second part illustrates the linguistic analysis of a pair of novice students' reflections for identifying their attitudes. Each sequence of the method introduced might be applied separately. The study shows that a rule-based approach to design incites attitudes of accountability among learners even in a short period. Reflection-on-action and reflection on (reflection-on-action) are two modes of advancing design metacognition, along with the commonly known design cognition mode of reflection-in-action, as introduced by Donald Schön. A variant of the Silent Game developed by Habraken & Gross (1988) followed for supporting the reciprocal reflection among learners in a social design process. The appreciative judgments of students expressed in their reflections, are analyzed through the *Theory of Appraisals* to highlight their accounts of designing.

Table 4.1 : The main references from which the method of the study is derived.

		Publication	Model
PART 1 Instilling Attitudes	Collective Reflection	**Schön, D. A., & Wiggins**, G. (1992). Kinds of seeing and their functions in designing.	*Reflection-in-Action*
			Reflection-on Action
		Habraken, N. J., & Gross, M. D. (1988). Concept design games.	*The Silent Game*
		Özkar, M. (2011). Visual schemas: pragmatics of design learning in foundations studios.	*Recognizing Visual Schemas*
	Tools	**Stiny, G.** (2006). *Shape: talking about seeing and doing*.	*Shape rules/visual rules*
PART 2 Identifying Attitudes	Linguistic Analysis of Reflections	**Martin, J. R., & White, P. R.** (2003). *The language of evaluation.*	*Theory of Appraisals*
		Halliday, M. A. K., & Matthiessen, C. M. (2004). *An introduction to functional grammar*.	*Transitivity Rules*
		Dong, A. A. S. (2008). *The language of design: Theory and computation*.	*Affect-in-Cognition*

In the method discussed below, shape rules are the pedagogical tools to scaffold the design studio discussions and enhance the collaborative practice in a structured manner. Students not only externalize one's design reasoning through shape rules, but they also reflect on which rules to use, to discard or re-interpret in their new designs. While the individual's reflections are usually recorded through verbalization (protocol analysis) as an approximation of the actual reasoning process, in this case shape rules serve to it. This study adopts the linguistic analysis technique of the theory of appraisals (Martin & White, 2007) to interpret students' written reflections accompanying shape rules.

A one-month-long study was conducted with first-year students asked to use shape rules while designing and at certain intervals to reflect on them. Protocol analysis was conducted on sessions based on shape rules and verbal reflections. Sessions of the students who wrote down their reflections on the shape rules were analyzed with the linguistic analysis technique of the theory of appraisals (Martin & White, 2007). Below is our assessment of the application of shape rules in students' design processes and discussion of the role of rules in enabling accountability and sharing among students.

4.3.1 The collaborative structure of the study

Fifteen volunteering first year undergraduate students of architecture took part in the study. The interaction between the students was structured for exclusive collaborative learning where students develop an awareness of their personal experience by comparing it to those of others. The medium of interaction among peers was limited to shape rules, and their reflections and interpretations.

In the setup of our main study with the students, students were instructed with a three-staged protocol, a variant of the design game "Silent Game" developed by Habraken & Gross (1988). It necessitates the participation of two makers A and B, as well as an observer C. A is tasked with making an organization that exemplifies a rule. B is then instructed to complete the design using the rule that he attributes to A. The concept design games were developed by focusing on a single aspect of design. The rules do not tell how to design but rather express intentions (like attitudes which are predispositions on how to act). Designing then is a social activity taking place among individuals who negotiate and make, follow, or discard rules for their conduct. In a nutshell, designing entails agreement-making and rule-making.

A later variant of the game was developed as a means of exploring what is involved in comprehending the rules inherent in a prototype (Porter et al., 1990). Accordingly, designers have access to prototype repertoires based on previous experiences. A recent variant of the game is adopted by (Özkar, 2011) in the basic design context. The Silent Game supports the divergent interpretation of rules as well as improves interaction among the participants in a social design process. Secondly, Moves meant to clear out ambiguities caused by variations in appraisal are sometimes ambiguous, fostering creative interpretations. Thirdly, the development of a unified, collaborative interpretation of prototypes is dependent on designers' reciprocal reflections. The participants' commitment to certain readings and the defensive reactions when their readings are put into question may undermine contemplation on design movements and descriptions.

This study follows a similar strategy to the Silent Game because it enables students to work in a collaborative social setting. Students are free to make up rules, follow or discard them without inhibiting the individual creativity. Yet, the structured set-up allows to be fragmented and to call into question the moves of the participants, hence holding them accountable.

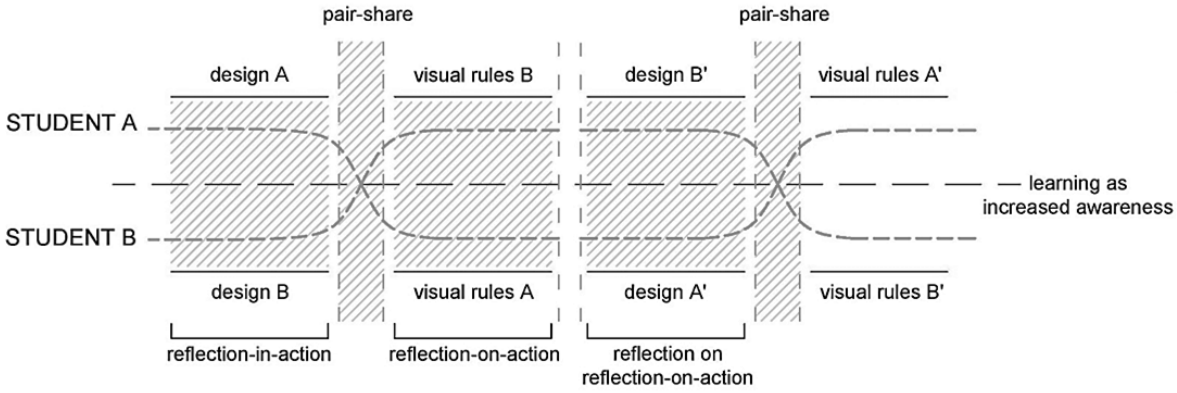


Figure 4.5: Collaborative scheme.

After an individual design mode, a pair-and-share mode would follow and switched back to the individual mode again. During Stage I, i.e., *reflection-in-action*, students were expected to perform an individual 2D design based on a given design brief. Next, In Stage II, students paired up for *reflection-on-action*. They exchanged their designs within the pair, and each was encouraged to reflect on what they assumed to be the design decisions of their partner from the previous stage. In Stage III, students were expected to follow and apply in a new design, the rules they identified in their partner's

work, hence *reflection on (reflection-on-action)*. The collaborative scheme is illustrated in Figure 4.5.

4.3.2 The collaborative practice: Reflecting and acting

In this study, collaborative design processes in volunteering first year undergraduate architecture students were comparatively observed over the course of a month in various types of group projects. Students were encouraged to externalize their thought processes through rules, as an important part for reflection. The initial stage helps acquire design skills, specifically reflecting in-action. The consecutive reflection phase is essential to deepen knowledge and build mental habits, awareness of thinking, and acting, hence reflection-in-action. In two tier tasks, students first completed a design assignment, then they were introduced to notion of visual rules while assessment. Students were then requested to understand and apply the work of others using visual formalisms.

The method was repeated in a series of tasks so that students might develop regular opportunities to appraise themselves and their peers. The tasks progress by adding a new variable in each stage. Towards the end of the process, they were expected to reflect on the collective and individual process comparatively, in terms of what rules they used and how changed their own rules on the way. This demonstrated that rule-based approaches to design help not only in dealing with form relations, but they become instrumental for the external interpretation of actions. Rule-based methods help establish cognitive strategies that create attitudes relevant within and beyond the design domain when viewed holistically.

In their first year at Epoka University in Albania, fifteen volunteers studying architectural design undertook the design experiment. For at least one semester, they were introduced to the design basics. The assignments are organized into two-dimensional formal compositions, which may be achieved within a specific boundary by cutting and pasting different forms. In addition, students are required to produce unified wholes as part of their design thinking skills. They should focus on the relationships between the design units yet maintain such elements' identity, while overlapping shapes. In addition, students are invited to see the forms arising from overlap and background as a contribution to the design while establishing relations

between shapes in various orders. The process and the outputs of the design episode are depicted in Figure 4.6.

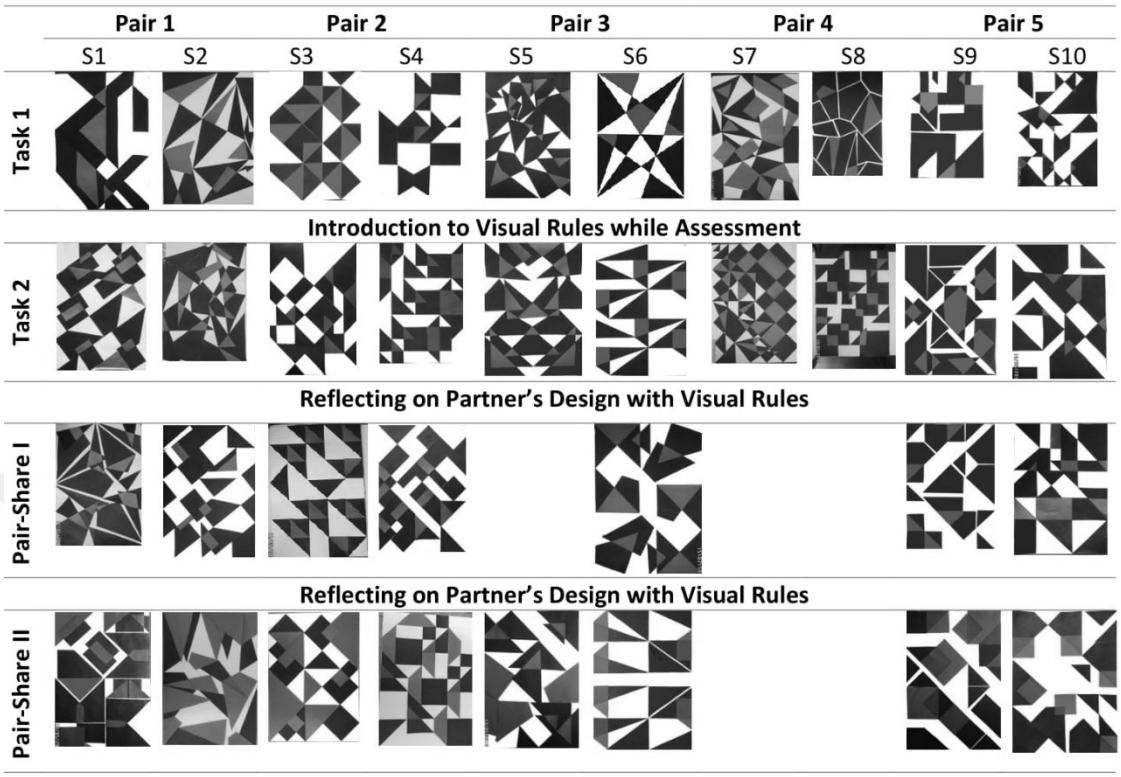


Figure 4.6: The workshop activity structured following the stages and the volunteering pairs.

The series of tasks were as follows:

1) In five successive steps, fold a sheet of paper.

2) Unfold the paper, emphasize the folding lines, and extract the emergent forms.

3) Make a two-dimensional design with seven parts generated from step 2; use each shape three times. Overlap is permissible. During a collective evaluation, students are exposed to visual rules while acknowledging probable rules in current designs.

4) Composing a two-dimensional design containing three of the components in stage 3; repeated seven times each. It is permitted to overlap. Swapping design with the peer. Identification of visual rules, potential patterns, and relations in the design organization. (Student 1 to Student 2 and Student 2 to Student 1).

5) Remaking of a two-dimensional design with three design components of the fellow, each repeated seven times. Students are requested to follow the rules in their fellow's design and implement them. Previous design requirements are relevant; The design

work should again be exchanged with the prior student. By employing visual rules, students are encouraged to identify possible recurring patterns and relationships in the composition: Student 1 to (Student 2 to Student 1) and Student 2 on (Student 1 to Student 2).

6) Creating a two-dimensional design by applying the rules defined in stage 5 to the three parts employed in stage 4. Besides the preceding design criteria, a red color component is added.

In a normal basic design studio, the tasks last shortly and progress quickly, each time introducing a new parameter. In this proposal, a slower and alternating approach was followed. Participants were asked to analyze the design relations with visual rules and reflect on them. The objective is to demonstrate to students that rules are a valuable instrument in formalizing their design thinking process and freeze possible decisions regularly. This interpretation enables students to share ideas and learn from one another, even without the assistance of an authoritative person. In the longer term, students are supposed to learn to scrutinize themselves. Related to the plethora of rules identifiable in a design, students have difficulty selecting which rules to apply. They were often urged to establish rules for the overall arrangement of the layout, the partial and part-to-whole relations.

The sequence of design tasks begins, as shown in Figure 4.7, with a folding activity. Students were instructed to fold the A4 paper in five successive steps without measurement tools. The haptic reaction is not considered. The folding paper might be a point of departure for students to introduce the concepts of embedding shape while beginning with a whole. Students repeatedly followed through on what was emerging from the preceding phase of folding. While the guiding principle of "the whole gets divided into its parts" was the same for all the students, the outcomes were varying.

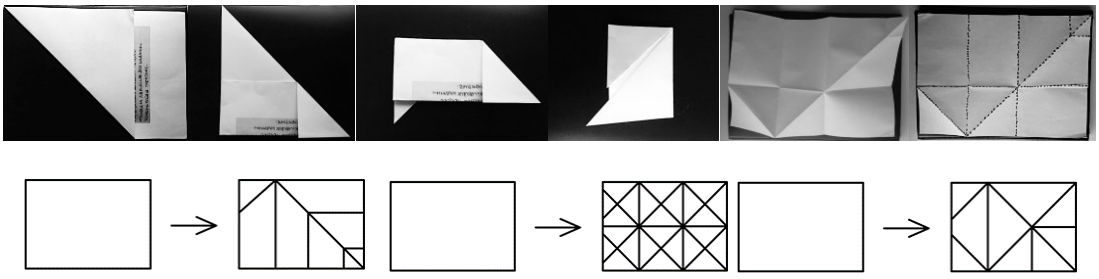


Figure 4.7: Various patterns of folding were created during the study by students.

In one successive phase, the participants were instructed to produce a single whole with seven forms derived from the layout of folded paper and to replicate each of them three times. For each student, the sub-forms vary. The key is in the making use of the relational system present in each folding pattern. Below, in Figure 4.7, are the illustrations for some of the students' works corresponding to this step. Students have not yet been shown how visual rules operate in a composition. Although some efforts were made by Student S1 and Student S3 to consider the background and the overlapping as design input, the organizations generally lacked order (Figure 4.8, Student S4) and non-repetitive shape-relations were prevailing (Student S2).

Figure 4.8: Stage 3 student work prior to exposure to visual rules. (Left to right: Student 1, Student 2, Student 3, Student 4 respectively).

At the end of Stage 3, students were introduced to the notion of visual rules in support of the panel discussions that usually take place for assessment. They were encouraged to perceive the process via formal devices like rules and depict them. The participants can control their design judgments and decisions when they see the entire design thinking process as computable. This is also possible due to the nature of two-dimensional design works taking place in foundation design studios, where compositions are achieved through geometric transformations of primitive shapes and settling relations between the different transformations.

Keeping in mind the potentials of visual rules, students were invited to redo Stage 3, as instructed in Stage 4. After the introduction to visual rules, Figure 4.9 illustrates the work of the same prior participants. The spatial relationships defined are improved from Stage 3 to Stage 4. This perception is relevant for more than half of the workshop group.

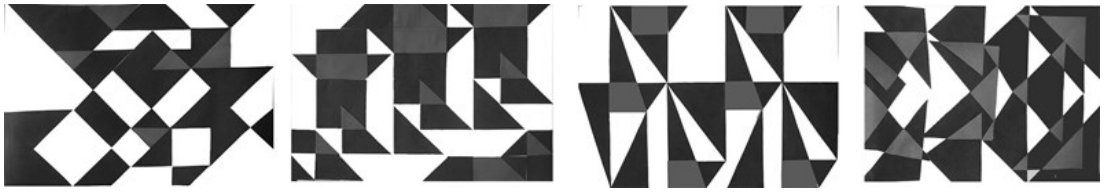


Figure 4.9: Design works of the same students, done in Stage 4, after being exposed to visual rules.

The comparison between the two groups of illustrations points towards more responsible acts taken by the students from Stage 3 to Stage 4, because of making use of visual rules in their personal design processes. Below follows an interpretation with rules of the design process of St 3, done retrospectively. The student work is re-drawn, disregarding the shape colors, as illustrated in Figure 4.10.

The interpretation of Student 3 design done in Stage 4 illustrates the possible visual rules to obtain St 3 work: a shape rule that indicates a recurrence and repeating application of the same rule. The alignment of the shape boundaries produces other forms to be perceived at another level. Additional rules show the canvas's height as a determining factor and another rule for assigning different weights to relate shapes in contrast.

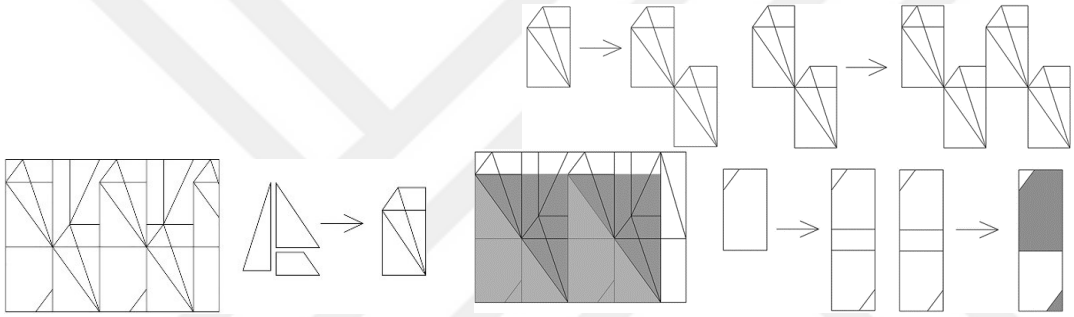


Figure 4.10: The interpretation of the St 3 work done in Stage 4.

The subsequent phases of the study supported the idea that visual rules contribute to the externalization of the design thinking process, hence sharing and accountability. The development of such attitudes necessitates the inclusion of collaborative learning like role playing. The design process was reversed at this stage. Participants were first required to identify specific rules that represent repetitive patterns and relationships in their fellow students in the compositions of Stage 4. While the second phase of reflection helps to gain design expertise, namely reflection-in-action, it is essential to develop an awareness of thinking and acting, i.e., reflection-on-action. Once the visual rules were identified, students were required to implement and apply the principles in a new composition by working in pairs. This process was repeated twice.

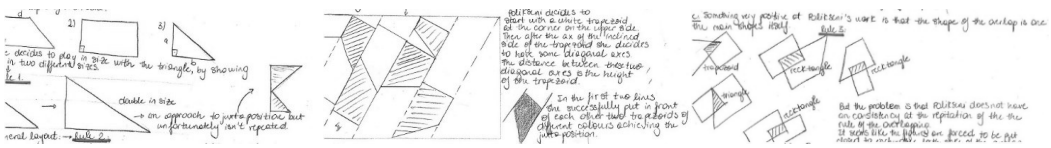


Figure 4.11: Interpretation of St 5 design using visual principles by her peer St 6.

Having students view their designs as visual computations enables them to examine and comprehend their design decisions and discuss them. In turn, students are empowered to evaluate critically and not blindly follow various design decisions. St 6 does not hesitate to comment in Figure 4.11 on any 'deficiencies' in St 5's design and interpret the composition using the rules. As illustrated in Figure 4.12, the parts are placed in alignment. St 6 recognizes and reapplies this spatial relationship in her Rule 2 by adapting the overall design to its bounds. As a result, in the second interpretation, the student handles the figure-ground relationship along the boundary better compared to the first.

Furthermore, Rule 3 and Rule 4 point to shape relations of overlapping and emerging parts. St 6 wrote: "Something very positive in St 5 work is that the overlapping part is one of the main shapes itself. But the problem is that she is not consistent in the repetition of Rule 3." St 6 also remarked on another rule, noting that the background is involved in constructing shapes that already exist. In many other situations, though, this approach does not follow through.

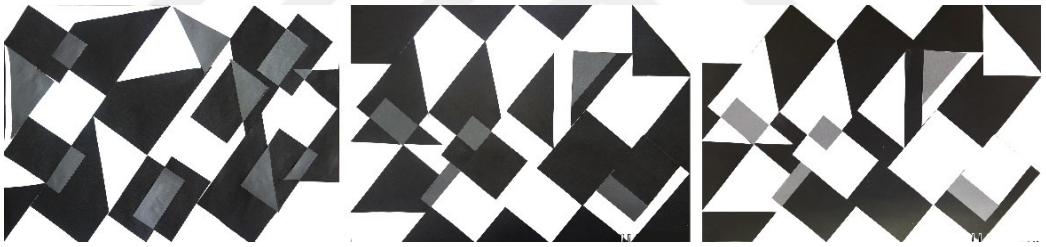


Figure 4.12: (From left to right) The design of St 5, as done in Stage 4; the interpretation of St 6 to St 5 design; the same composition as in the middle, but with different weights.

These remarks again demonstrate the opportunities of visual rules when included in the studio talks. Student S6 not only interpreted design actions with references to visual rules but was also able to produce arguments for why some relations were good and why some were not. While there is room for improvement, it is evident that the second student's perspective on the first one is more congruent with the original goals. The study shows that ten out of fifteen students acquired more conscious, consistent assessments of the work of their colleagues. The students articulated their views and took account of the thoughts of the other students when they extracted rules and reapplied them.

This research emphasizes attitudes that ideally complement the acquired knowledge and skills but are often left tacit. The goal is to include attitudes into the learning

process instead of the conventional notion that attitudinal training is a valuable skill for graduate students. It focuses on developing attitudes that pertain to knowledge sharing and accountability of the design decisions.

Accountability is defined as the responsibility for performance, or the obligation to report to others, to explain, to justify the taken actions (Huisman & Currie, 2004). The underlying assumption is that letting students view their designs as visual-spatial computations helps them realize what they do, how they do, and most all, why they do things the way they do. Moreover, rules that capture the visual stages of a transformation externalize knowledge to be shared and to be questioned at various instances of design and production. Previous studies have acknowledged the role of formal tools like visual rules in externalizing the design thinking process in support of the "reflective practice".

In this research, fifteen first-year architecture students were observed with the aim of assessing attitudes. Students utilized visual rules to reflect on their processes of design and their fellow students and to define or recognize different form relationships. Although some of the participants did not create a single whole, as shown in Figure 4.13, all participants were able to determine and relate parts at an even degree. Student 2 says that he felt confined as he did the same composition again while reapplying the rules of his fellow. This might be related with the abundance of rules identified in a composition and their specifications.

Figure 4.13: (From left to right) Design work done in Stage 4 by St 1; its re-interpretation done by St 2 in Stage 5; design work done by St 1 in Stage 6.

Nevertheless, participants attempted to be mutually responsible by working in pairs. For example, one of the students in the post-experiment discussions said that the whole process was highly individualized, although they worked on each other's designs. One can now quickly distinguish the work of their fellow among many others.

It implies that participants learn to grasp the differences and the thinking process of others in interaction with each other. By seeing their steps as a reflection, students

become aware of whether they do things differently or similarly by comparing their learning with others. It may be further extended toward the function of the rules as illustrated in the folded paper exercise in establishing personal styles and plurality in design. The study revealed how students might learn how to be accountable to others through computational approaches to design. The overall goal is to get learners to understand how to practice attitudes in different environments. Previous studies have acknowledged the difficulty of assessing attitudes as they are a time-dependent competency.

What follows below is a close-up observation of a pair of novice students' interactions. Its analysis is structured according to the sequence of stages, namely: I. *reflection-in-action*, II. *reflection-on-action*, and III. *reflection on (reflection-on-action)*. The following part illustrates the linguistic analysis of the students' interactions.

4.3.2.1 Stage I: Reflection-in-action

The students in the study had already been exposed to the basics of design for one semester. The initial two-dimensional design tasks given in the study were structured around a limited number of shapes, adding each time a different restriction as the assignments progressed. Students were asked to organize a certain given number of shapes on the canvas. The objective was to define relations at different levels by keeping unified the whole composition. Part relations constitute an important aspect of visual design computing. Part to part relations may recur in terms of how these parts relate with the whole. As the two-dimensional compositions in basic design are additive in approach, placing a shape on canvas, evokes reflection for the next action, hence *reflection-in-action*. The students did not have prior knowledge of shape grammars and shape rules. Shape rules were briefly introduced to students while reviewing their designs which were completed by the end of Stage I.

4.3.2.2 Stage II: Reflection-on-action

The task in Stage II started with a finished design, asking students to reflect on the possible actions of their partner. Students exchanged their works in pair, to reflect on the possible decisions taken by their corresponding partner. Students were explicitly required to identify possible relations of abstract shapes through visual rules and accompany each design with a rules' sheet as illustrated in Figure 4.14. From here onwards, this part reports on the process of a pair of students, Student A and Student

B, selected out of the fifteen volunteers based on their effective and articulate use of two modalities, written and visual, in their documentation. Selecting a few individuals out of a certain group is a method adopted for the study of short design episodes (Goldschmidt, 2001). While shape rules come in the format of Shape A → Shape B, here the representations of visual relations are accepted as adequate manifestation of rules. Student A identifies rules of recurring parts and shape alignments. These rules are illustrated in the following part, by comparing what rules Student A identifies, keeps, or discards in her new design.

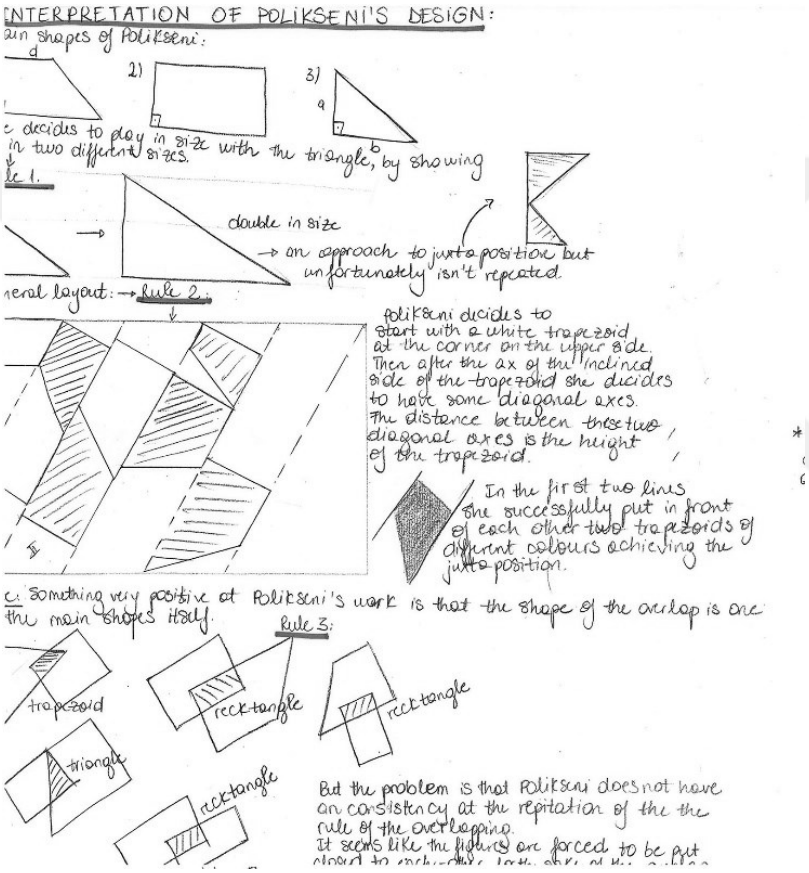


Figure 4.14: A rule sheet sample from Student A produced during Stage II: *reflection-on-action*, while reflecting on her partner's design.

4.3.2.3 Stage III: Reflection on reflection-on-action

In the last stage, students are asked to follow and re-apply in new designs the visual rules identified in Stage II. Student A proposes a general rule which Student B might have used for the organization of the layout of composition. She refers to how parts align with one another and specifies this relation parametrically as follows: *"Student B starts with a trapezoid at the corner on the upper side. She has some diagonal axes according to the inclined side of the trapezoid. The distance between the two axes is*

the height of the trapezoid." The relations are depicted by Rule 4 and Rule 4' respectively as shown in Figure 4.15.

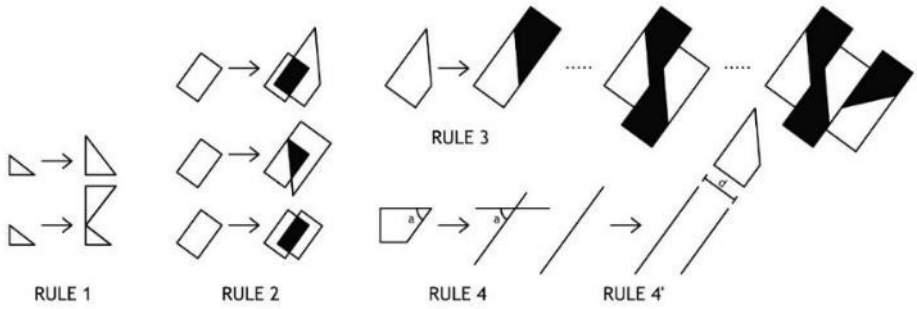


Figure 4.15: Visual rules as identified by Student A during the *reflection-on-action* stage.

Although parts align according to two different axes, Student A acknowledges only one of them and reemploys it in her new composition. The result is a very similar composition with little changes as shown in Figure 4.16. She has omitted some shapes and emphasizes more the alignment between parts. The boundary rules allow to switch the focus from a planar shape to its outline or boundary and make them part of the visual reasoning.

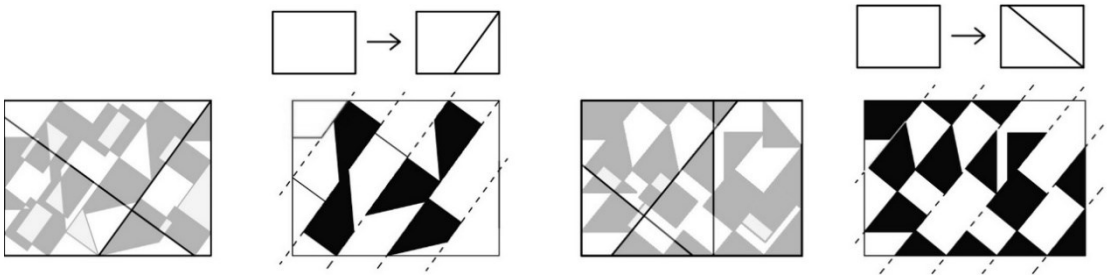


Figure 4.16: Visual rules specifying the general organization layout, based on the visual analysis of both students.

Student A makes use of the boundary rule (Rule 3) by transforming the boundaries (marked in red) into a shape in her consecutive new design. Similarly, Student A identifies the background and the emerging parts of the overlapped shapes (Rule 2), as a new design input. However, Student A points to the lack of any relation between the recurring parts: *"The problem is that Student B does not have any consistency in repeating the rule of overlapping."*

Referring to the example of reading the figure-ground in terms of trapezoidal shapes, Student A reads them as a grouping of elements in her friend's work: *"Student B puts repeatedly in front of each other two trapezoids of different tones, achieving*

juxtaposition." Student A reemploys this rule in her new composition by switching the tones of the figure and ground. She repeats and relates the groups of elements through translation as a variation of the second student's design.

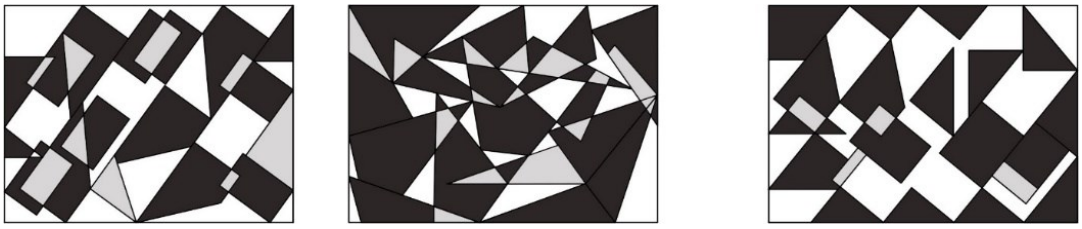


Figure 4.17: Two-dimensional abstract compositions produced by Student B (left) and Student A (middle) during Stage I; (right) composition produced by Student A based on Student B's design during Stage III.

Encouraging students to give accounts of their designs through computational formalisms fostered an open sharing, praising, or scrutinizing one's own position as well as others. As a group of peers all participating students were exposed to different understandings of the same design problem. When asked to reflect on the work of their matched peers to identify and represent relationships of abstract shapes through shape rules, most of the students focused on recurring parts and shape alignments. As illustrated in Figure 4.14- Figure 4.17, it shows the work of Student B for Stage I, the partially rule-based interpretation of that work by Student A for Stage II, the work proposed by Student A for Stage III and based on that interpretation. Student A reads the figure-ground relations of the trapezoidal shapes in Student B's work as a consistent set of elements and employs this rule in her new composition while varying the tones of the figures and the ground.

4.3.3 Identifying accountability in reflections

Following the three-staged design exercise, I sought for evidence as to whether students felt accountable towards their peers by analyzing how students assess the process in their verbal reflections. Even if it was inconclusive due to short duration and cannot be generalized regarding a limited number of participants, this was an attempt to test a way to assess attitudes in the studio. Previous studies (Dong, 2006; 2008), which discussed how designers assessed the process of their design practice, have employed linguistic analysis technique to analyze design protocols.

According to the theory of "language of evaluation," attitudes are the most important resource of taking evaluative stances through affect (emotions), judgment (ethics) and

appreciation (aesthetics). Martin & White (2007, p. 45) see judgment and appreciation as *"institutionalized feelings"* that bridge *"the common sense with the uncommon sense worlds of shared community values"*. Affect refers to what someone feels in contrast to appreciation that stands for the power to cause such feelings towards things. Similarly, while judgment refers to a capacity, appreciation is about the evaluation of things. In the collected data, Student A writes *"...she successfully put…"* in an attitude as judgment of a capacity, and *"...the shapes are forcibly put close to each-other…"* in an attitude as appreciation and valuation.

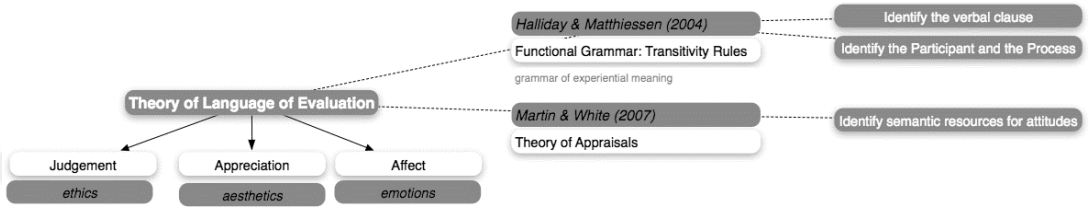


Figure 4.18: The combination of Transitivity Rules and Theory of Appraisals are used to analyze students' design protocols.

In this study's data, attitudes are realized in a range of grammatical forms: Student A writes *"...unfortunately, it is not repeated..."* using an adverb as a comment adjunct, *"...something I have noticed is..."* using a verb as process, and *"...something very positive at Student B work is…"* using an adjective as epithet. The transitivity or the grammar of experiential meaning system interprets personal pursuits into a controllable collection of process types such as material (doing, making), mental (thinking), and relational (having, being) (Halliday & Matthiessen, 2004). Participant, i.e., the subject of the verbal clause, is coded based on process types.

The combination of semantic meaning and grammar guide the coding scheme of the text chunked into verbal clauses under inquiry. The steps of the analysis are: 1) identifying the verbal clause, its Participant and Process by using the transitivity rules (Halliday & Matthiessen, 2004); 2) identifying semantic resources for attitudes by referring to the theory of appraisals (Martin & White, 2007). A verbal clause analysis from the study is shown in Table 4.2.

Table 4.2 : An exemplified verbal clause analysis.

Clause	**"But**	**unfortunately,**	**it**	**is not repeated**
Step 1	Conjunctive Adjunct	Comment Adjunct	Participant: Carrier	Process: Relational, attributive
Step 2	Graduation: Force/negative Attitude: Affect			Attitude: Judgment

The clause illustrates an evaluative stance expressing an attitude (affect) with negative orientation using the word *"unfortunately."* The comment adjunct implies the speaker's attitude towards the whole message. The same clause invokes an attitude through judgment on a shape transformation which *"is not repeated."*

Similarly, I searched for attitudes in evaluative stances in language through affect (emotions), judgement (ethics), and appreciation (aesthetics). The verbal clause analysis is applied to the whole written material produced by Student A, as illustrated in Table 4.3. The cipher for indicators used in the tables below is as follows: bold font – the written reflection of student; the underlined text – the descriptive clause; text within [] brackets – Attitudinal Position; text within curly braces {} – Process.

The reflection text is not a report of what student A sees in her partner's design, but an interpretation of what she thinks she sees. There are moments of uncertainty in her reasoning which are evident in the text through her Heteroglossia engagement. Using *"it seems like," "there is an approach," "I have noticed,"* the student presents the propositions as but one of a range of possible positions. In other cases, she positions herself as being at odds with what her partner has done. The frequent use of the adjunct *"but"* is an indicator of counter-expectancy which "acts to alert that attitudinal values (positive/negative) are at stake" (Martin & White, 2007).

Verbal clauses of appraisal and verbal clauses which are descriptive and of a subjective content are separate. In cases when some terms under appraisal are non-attitudinal, they are intensifying (e.g., successfully) or quantifying (e.g., some, many). Sentences which acknowledge a shape relation are usually descriptive clauses with no attitudinal stance, as exemplified in Table 4.4. However, those sentences evoke attitudes as displayed in the text, mostly through judgment and appreciation.

As illustrated in Table 4.3, Student A was able to externalize with visual rules the possible decisions taken by her respective partner. Her visual rules were associated with written reflections which either praised or disapproved aspect in her partner's work. Externalization in one situation alone was not enough in recognizing a consistent attitude and a consecutive application of the observed understanding is sought in a following situation. In the case, students were directed towards exchanging the compositions produced in each stage and followed a back-and-forth process in between analysis and synthesis.

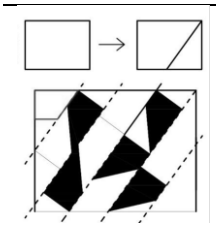
Table 4.3 : Linguistic analysis of the written reflections of Student A in Stage II.

Linguistic Display of Attitude
"**She** (Senser) **{decided to play}** (Process: Mental, intention) in size with the triangle **by showing** (Process: Material) **it** (Scope) in two different sizes (Descriptive clause) ... [**an approach to juxtaposition]** (Engagement: Heteroglossia) (Attitude: Judgment)
But **[unfortunately]** (Comment Adjunct) (Attitude: Affect) **it** (Carrier) **{is}** (Process: Relational, attributive) **[not repeated]** (Attribute) (Attitude: Judgment)."
"**Student B** (Senser) {**decided to start}** (Process: Mental, intention) with a white trapezoid at the corner on the upper side (Descriptive Clause).
Then, after the axis of the inclined side of the trapezoid (Descriptive Clause) **she** (Senser) **{decided to have}** (Process: Mental, intention) some diagonal axis (Phenomenon) (Descriptive Clause).
The distance between these two diagonal axes is the height of the trapezoid. (Descriptive clause)
In the first two lines **she** (Actor) **[successfully]** (Graduation: Force) **{put}** (Process: Material) in front of each other two trapezoids of different colors (Scope) (Descriptive clause) **[achieving the juxtaposition]** (Attitude: Judgment)"
"Something [**very positive]** (Attribute) (Graduation: Force) (Attitude: Judgment) **about Student B's work** (Carrier) **{is}** (Process: Relational) that the shape of the overlap is one of the main shapes itself (Value) (Descriptive clause).
But **the problem** (Carrier) **{is}** (Process: Relational, attribute) **[that Student B {is} not consistent about the rule of overlapping.]** (Attribute) (Attitude: Appreciation)
It (Carrier) **{seems}** (Process: Relational) **like** (Engagement: Heteroglossia: leaving open the option to negotiate with the reader/oneself) (Attitude: Appreciation) **the shapes** (Scope) **[{are forcibly put}]** (Process: Relational, Attributive) **close to each other** (Attribute) (Attitude: Appreciation/Judgment) [f**or the sake of] overlapping.** (Graduation) (Attitude: Affect)"
"**Also, something [positive]** (Attribute) (Graduation: Force) (Attitude: Judgment) that **I** (Senser) **{have noticed}** (Process: Mental) (Engagement: Heteroglossia) **{is}** (Process: Relational) that **there is an approach** (Heteroglossia) of the background participating [**itself]** (Graduation: Focus) **to form shapes** (Descriptive Clause) **that already** (Engagement) exist.
But **this approach** (Carrier) **{is}** (Process: Relational, Attributive) **lost** (Attribute) (Attitude: Appreciation/Judgment) **in [many]** (Graduation: Force) **other cases**.
Sometimes (Modality) **[some]** (Graduation: Force) **strip lines** (Scope) **{are formed}** (Process: Material) and **the eye** (Carrier) **{gets}** (Process: Relational, attributive) **[lost and confused]** (Attribute) (Graduation) (Attitude: Appreciation/Judgment) **on reading the shapes**."

Student A particularly met the expectations in reading many rules in her partner's design, hence producing ample documentation of that process. She sometimes displays a convergence as if to be accountable for understanding and validating what the other student did, whereas other times her divergence is a critical reflection that seeks accountability from the partner. The reflection text is not a report of what student A sees in her partner's design, but an interpretation of what she thinks she sees. There are moments of uncertainty in her reasoning which are evident in the text through her Heteroglossia engagement. Using *"it seems like," "there is an approach," "I have noticed,"* the student presents the propositions as but one of a range of possible positions. In other cases, she positions herself as being at odds with what her partner has done. The frequent use of the adjunct *"but"* is an indicator of counter-expectancy which "acts to alert that attitudinal values (positive/negative) are at stake" (Martin & White, 2007).

Verbal clauses of appraisal and verbal clauses which are descriptive and of a subjective content are separate. In cases when some terms under appraisal are non-attitudinal, they are intensifying (e.g., successfully) or quantifying (e.g., some, many). Sentences which acknowledge a shape relation are usually descriptive clauses with no attitudinal stance, as exemplified in Table 4.4. However, those sentences evoke attitudes as displayed in the text, mostly through judgment and appreciation.

Table 4.4 : An example of a shape relation as a descriptive clause with no attitudinal stance.

Shape Rule	**Descriptive Clause**
	"Student B decided to start with a white trapezoid at the corner on the upper side."
	"Then after the axis of the inclined side of the trapezoid she decided to have some diagonal axis.
	There is an approach of the background participating itself to form shapes that exist.

As illustrated in Table 4.3, Student A was able to externalize with visual rules the possible decisions taken by her respective partner. Her visual rules were associated with written reflections which either praised or disapproved aspect in her partner's work. Externalization in one situation alone was not enough in recognizing a consistent attitude and a consecutive application of the observed understanding is sought in a following situation. In the case, students were directed towards exchanging the compositions produced in each stage and followed a back-and-forth process in

between analysis and synthesis. Student A particularly met our expectations in reading many rules in her partner's design, hence producing ample documentation of that process. Student A sometimes displays a convergence as if to be accountable for understanding and validating what the other student did, whereas other times her divergence is a critical reflection that seeks accountability from the partner.

In the verbal clause analysis (Halliday & Matthiessen, 2004) I conducted for the whole written material produced by Student A, the student sometimes generously referred to student B's propositions as possible positions to the problem at hand. This may be because she was aware of being the same position as her work was simultaneously being analysed by Student B. In other cases, she positioned herself in contradiction with what her partner has done, as evidenced by the frequent use of the conjunction "but". Sentences that acknowledge a shape relationship were usually descriptive clauses without attitudinal stances. However, these sentences evoked attitudes that were displayed directly in the text, mostly through words of judgement and appreciation such as "successfully". Student A, at times, understood and validated what the other student did, whereas at other times her divergence is a critical reflection that demands accountability from the partner. This verbal reflection supports Student A's take on the work of Student B, where she traces the rule established by Student B with respect but varies certain aspects of it introducing her own language of design. Along with the impact that collaborative and reflective learning experiences have on attitudes, the relational thinking of design incites attitudes of accountability as well.

4.4 Accountability in Relational Design Thinking: Meno in the Studio

This part focuses on the role of computation in providing an instrumental medium for attitude development and assessment in the design learning settings of the future. It focuses on visual reasoning and reflective learning as they feature strongly in the passage on a mathematical inquiry in Plato's Meno (Plato, 1985). This part covers attitudes noticed among participants of beginning design studio when they role-played. It indicates that analog computing enables the external manifestation of reasoning in foundation studios and encourages the starting point of accountable designing.

A basic design studio is a primary setting for learners to acquire and develop their design competencies. One aspect of their achievements consists in developing attitudes

of accountability through utilizing referential and relational design thinking. Accountability in a university context is a feature typically looked for at administrative rank and defined as “answerability for performance” (Romzek, 2000).

Accountability involves a moral dimension in learner-centered higher education (Monson, 2005) and profession afterward. In addition to practical and professional education, Findeli (1994) describes this component as a universal morality to be taken independently of the field of design. As students gain their knowledge of the values of specific acts, they achieve attitudes and reflective skills.

It is suggested that a formalistic approach to design is significant for instilling attitudes based on two arguments. First, as described by Stiny (2006), visual rules represent limitations self-imposed by the designer to relate or alter shapes in a design. The use of visual rules as instruments for thinking in the studio enables learners to explain their design thinking and improve awareness and understanding. Furthermore, rules that visually record the transforming phases of a design exteriorize it for communicating and challenging the occurrences of designing and making. Schön (1983) characterizes design as a reflective conversation providing a better knowledge of that particular circumstance through reflecting and acting. It is argued that externalizing the design thinking process promotes reflection and consequently the formation of some attitudes in design learning.

Referring to Schön’s model of reflection, this section derives from an excerpt from Plato’s Meno (1985), a Socratic dialogue. While the full breadth of pedagogical values and Plato’s theory of learning as recollection inherent in Meno deserves special attention and discussion, our focus is on the part concerning a slave boy and the drawing of shapes on the ground. This part of the dialogue provides an illustration of development of an understanding, and reflection plays an indispensable role in it.

From a design thinking perspective, Schön (1987) acknowledges that the Meno conversation is built upon a range of interconnected educational processes: showing, understanding, reflecting, and acting. Socrates and the boy engage in verbal and visual interpretations, as is the interplay among the instructor and the design studio learner. Schön recognizes the “learner’s paradox” in Meno in parallel to the experience of learning to design: “Like Meno, the design student knows that s/he needs to look for

something but does not know what that something is. S/he seeks to learn it, moreover, in the sense of coming to know it in action."

Socrates observes recollection when he questions the boy to double the square surface. In a systematical and graphically supported way, the inquiry is essential in establishing argumentation. The geometrical constructs on the ground depict the process of thinking by combining and changing forms. The boy's progressive understanding of the relational structure and order behind the forms helps his thinking and awareness. A person's understanding-in-action is the narrative of the discourse. In the same way, the visual rules which exteriorize relational design thinking are instruments not just to manage relations but also to build solid design competencies for beginner designers. The boy in the dialogue tacitly learns the relations of the squares in the Pythagorean Theorem.

Similarly, forms in designs have an inherent structure as they are interrelated. Any shape organization is visually identified per se when a spatial connection is established. Drawing rules as discrete steps of a computation formalizes thinking and generative processes of design as previously developed and applied extensively within the frame of shape grammars (Stiny, 1980; Knight & Stiny, 2001).

While the whole scope of pedagogical principles in the conversation is appreciated, the focus is on the duplication of the square problem presented to the slave-boy as an example of a problem-based learning. The passage on the geometrical inquiry is crucial in improving reasoning gradually. The discourse acts are reconstructed using shape rules to illustrate the progress towards a more profound understanding contributing to attitude development.

4.4.1 Interpreting *Meno* from a computational perspective

Shape rules in the context of visual computing are visualizations of a shape's specifications and attributes. Similarly, the geometrical relationships delineated in the passage are visually perceptible and call for expression with visual rules. Previously, March (1999) recognized the link between Plato's mathematics and the visual computation concerning the *anthyphairetic* ratio of the diagonal and the edge length of a square. The communication between Socrates and the boy on how to get a square twice the size of a specified square is visually depicted below via visual rules (Figure 4.19). Throughout the dialogue, Socrates directs questions at the boy about spatial

relations. Rather than the result, he asks for the means for them and makes the boy trace the course of logic and arrive at a certain level of understanding. The original dialogue does not include any images, but it is assumed that Socrates performs it by depicting the drawings on sand, and many publications have introduced images in line with the text.

The conversation begins with the question of Socrates on whether the boy recognizes a square shape: *"Tell me, boy, do you know that a square is like this?"* suggesting, however, that it is comprised of four equivalent lines, as shown in Rule 1. The following question: *"And these one's going through the center are also equal?"* concerning the relations between diagonals and the square itself coincides with Rule 2, demonstrating the center concept. Rule 2 allows for perceiving *"larger and smaller versions of"* the square area when applied recursively as expressed in Computation 1. The square is subsequently split into two and four equal parts. Socrates assumes the youngster recognizes this and can infer the relationship between the area and the edge length of a square shape. Various interpretations of the same question directed to the boy by Socrates on the area-side relationship follow: *"Now, if this side were two feet and this side two feet also, how many feet would the whole be? Or, if this one was two feet but this one only one foot, wouldn't the area have to be two feet taken once? When this one is also two feet, there would be twice two?"*

Next, Socrates doubles the area of the first square following an additive approach. Rule 1 runs recursively to one side of the original form and emerges as a rectangle in the second phase of Computation 2. Whenever Socrates informs the youngster of the shape rules set in earlier phases, he presents the idea of learning as recollection. Repeating Rule 1 in Computation 2 leads to a square but one that is too large rather than the double.

By the end of the conversation, Socrates reveals the answer to the present dilemma: *"But we need to produce double. Now is not there this same line, going from corner to corner, cutting each of these areas in two?"* As an option to Rule 2, Rule 3 splits the squared space into identical portions with the same axes passing across the middle. The repetition of Rule 3 turns the square into four equal parts as in Computation 3. When used in conjunction with Rule 2, the outcome is an arrangement of triangular shapes. Rule 3 is used to produce additional triangles in a successive iteration in Computation 4. Next, Socrates requests the boy to recall Rule 1: *"So there will be*

these four equal lines, enclosing this area?" Computation 5 exemplifies how the diagonal axis of a preceding square is the side of the consecutively generated larger square.

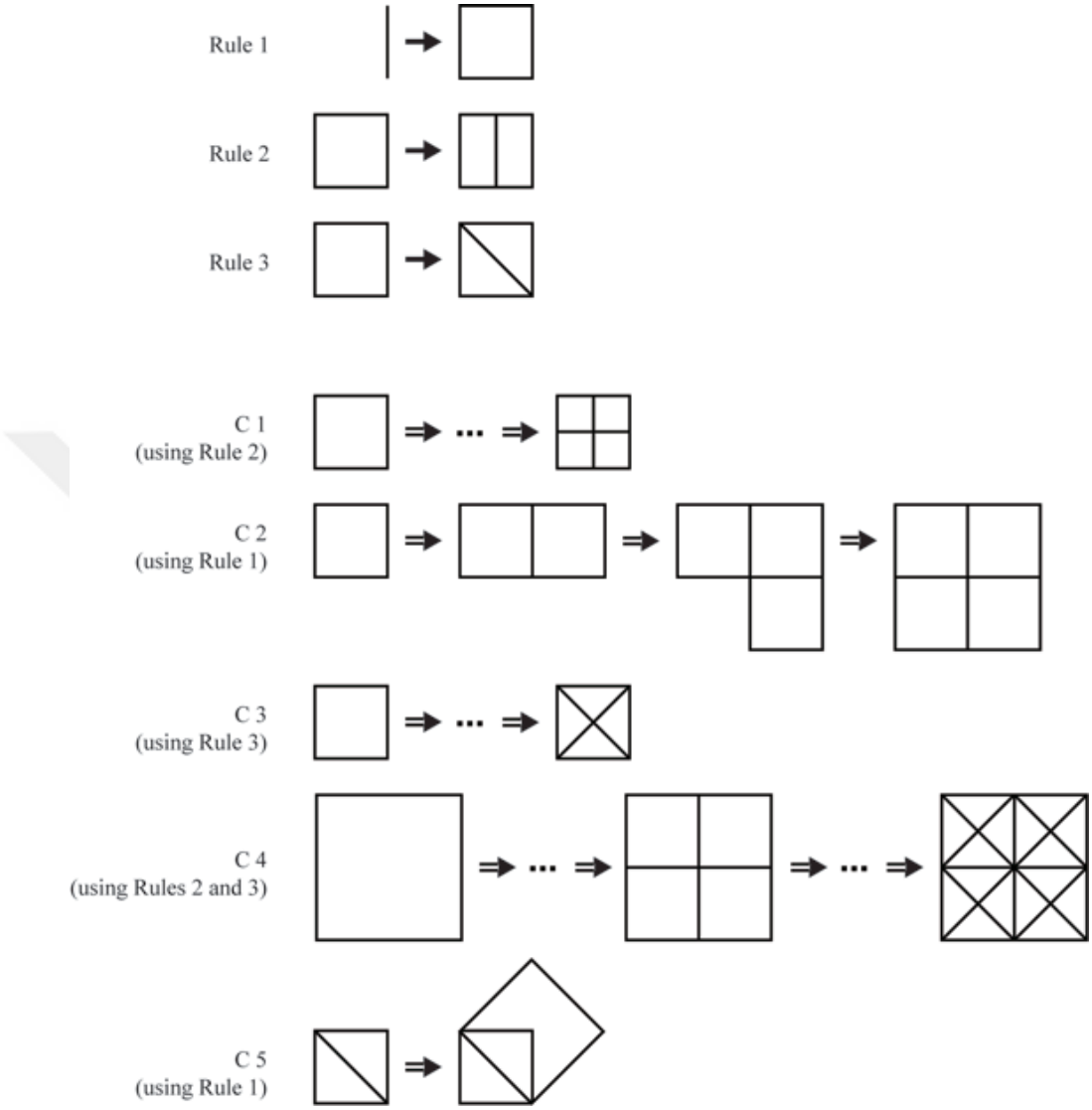


Figure 4.19: Meno's three visual rules and a variety of conversational visual computations.

The conversation concludes with Socrates, who recapitulates how the diagonal axis generates the double area. All the while, the responses provided by the boy were his conviction attesting to learning as recollection: *"What do you think, Meno? Is there any answer that he gave that was not his own belief?"*

4.4.2 Playing *Meno* in the design studio

Students in their beginning design studio are introduced to diverse abstract assignments to determine relationships between shapes in different design orders. The

formal vocabulary used to deliberate these relationships supports thinking while learning, like the interaction in *Meno*. In a short design study, eleven volunteering second-year architecture students from Epoka University in Tirana, Albania, participated in three phases (allocated over three months). Students had a previous experience on working with shape rules. The dialogue of Meno served as a guide to understand the relational nature of design as well as to formalize the students' individual design thinking processes as conducted in the assigned design tasks. The phases of the study were as follows:

- Phase 1 (day 1.): Students are asked to read the dialogue and interpret the moves with shape rules. They are invited to think about the passage and apply the visual rules in a two-dimensional design. The design is organized on certain elements, the sizes of which must be determined by them (individual task).
- Phase 2 (3 months later): In a pretend play, participants must persuade a customer to acquire a two-dimensional abstract design made by one of their colleagues at Phase 1. They are invited to argue the formal features of the design in a group and articulate their ideas. (2 groups)
- Phase 3: Students are asked to work in pairs and make a short design task by using the exact element sizes as in the design they remarked on in Phase 3. (4 pairs)

The design tasks of Phase 1 and Phase 3 comprise two-dimensional compositions in a figure-ground relationship with black and white contrasts through the cut-and-paste technique. The selected shapes from the dialogue have a special proportional relationship among their parts, allowing the combination of forms as illustrated in Figure 4.20.

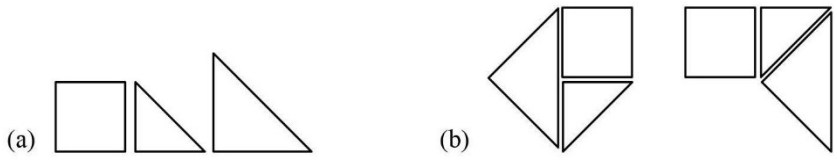


Figure 4.20: (a) The selected shapes and (b) the various combinations of forms.

4.4.3 Exemplifying a personal design process through formalisms

In Phase 1, students are expected to interpret the passage between Socrates and his interlocutor. They are then invited to create a two-dimensional design considering the alterations and shape relations in the conversation. Participants must judge and decide

the consistent size of the shapes to be employed in composition and select for themselves. Like the visual reasoning Socrates directs the boy through in the passage, visual rules depict the thinking processes of the participants in the design tasks performed in studios.

Following is the interpretation and externalization of the student S1's design process through shape rules. The analysis begins with the overall arrangement to continue with the part-to-whole relations in the design. S1 arranged the entire surface to a grid of 7 x 10 units (Figure 4.21). The size of the unit is determined by the smallest triangle. In the given shapes, the smaller triangle is half the size of the larger one. Like what Socrates refers to in "And so there would be larger and smaller versions of this area?" shapes appear in different sizes.

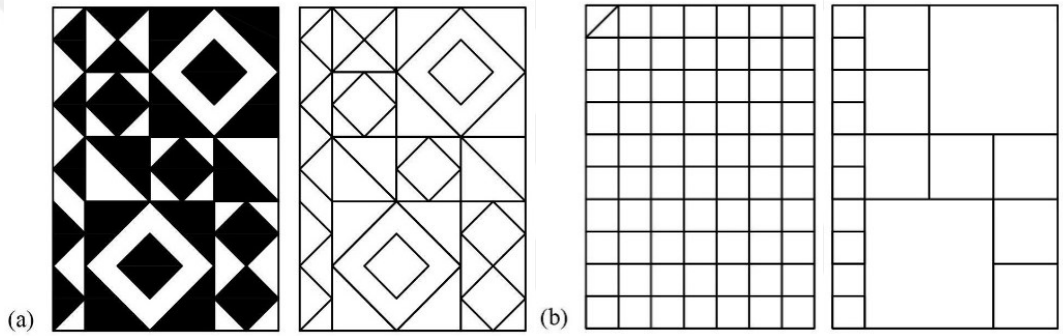


Figure 4.21: (a) The design output of St 1 depicting only the shape contours. (b) The referential system of S1 composition.

The relational system is reinterpreted in the following step. S1 has grouped four adjacent squares into a larger square resulting in a combination of 1-unit and 2-unit square systems in the first run, and a combination of 1, 2 and 4-unit square systems in the second run. The grid system developed by the student helps in reading different parts of the composition proportionally related with one another. At a first glance, the individual parts strike attention because S1 has followed the grid rigidly. However, in a second instance, the act of recursively sizing the square elements displays repeating units with some variation.

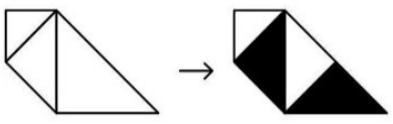


Figure 4.22: A shape rule in S1 composition allocates shades to forms, enabling the big triangle to be seen in parts.

4.4.3.1 Visual relations and emerging squares

The process of creating an emergent square out of the constraints of the given elements is achieved by either combining other shapes, or/and by playing with the contrast between figure-ground relationships. These combinations lead to squares of different sizes and orientations, Figure 4.23. Whilst the square is one of the three given forms, squares of other sizes can be defined like what Socrates by relating shapes and enclosing square areas according to Rule 1: *"And so a square has these lines, four of them, all equal?"*

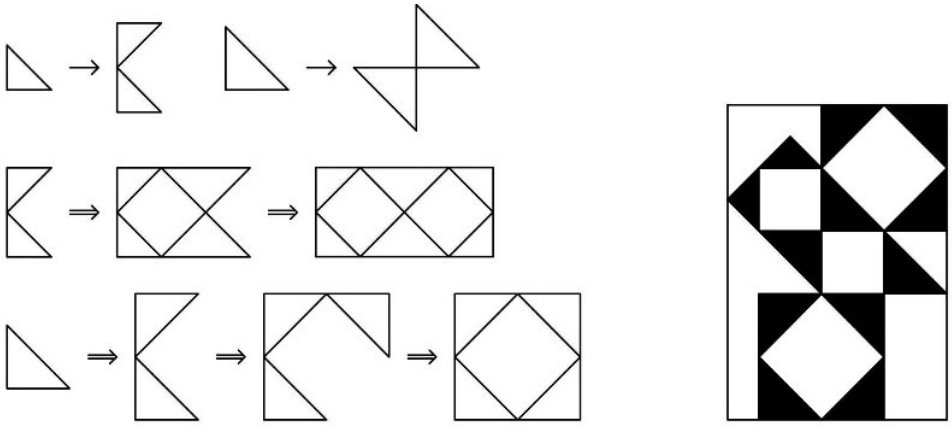


Figure 4.23: S1 has generated novel squares of various sizes with the potential pairings of given shapes.

Another way student S1 has used to define squares is by applying Rule 3 "*And these ones going through the center are also equal?"* The student has played with the figure-ground relationship achieved when a triangular shape sets a relation with the background. As seen in Figure 4.24, the merging of figure and ground allows the impression of squares of different dimensions and positions. The student perceives embedded squares in various shapes.

The reason for Socrates' argument with the boy was the search for a square twice the length of a certain square. This relation is enacted in the design of S1 in two alternative moments. Two instances are defined in Computation 5 at the end of the dialog: (1) how two squares relate in terms of size, and (2) how two lines relate with each other: the diagonal of the smaller square, becomes the side of the larger square.

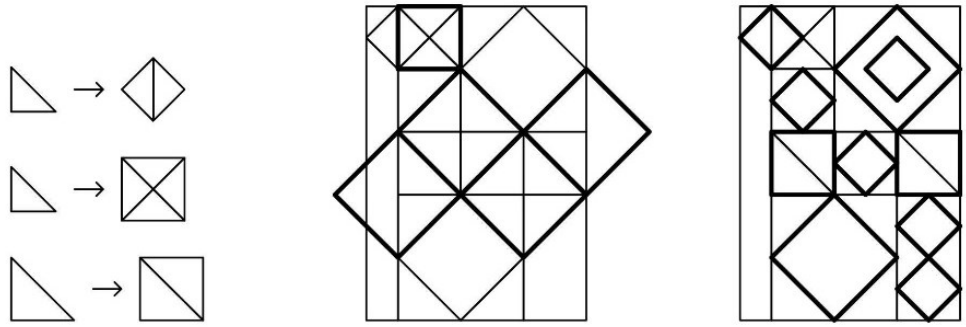


Figure 4.24: Rule 3 is interpreted in multiple instances of relating triangles in contrast and achieving emerging squares.

Beginning with the second instance, the relationship between the diagonal becoming the side of a larger square is visually emergent throughout the composition. For S1, Computation 5 has generated a different shape rule depicting superimposed squares of varying sizes all over the composition. However, S1 has not managed to repeat relations at various design orders.

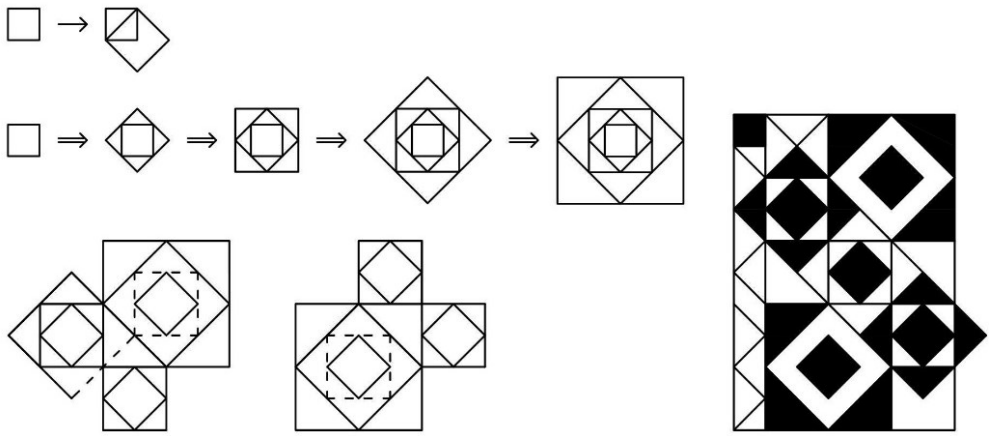
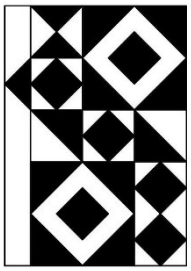
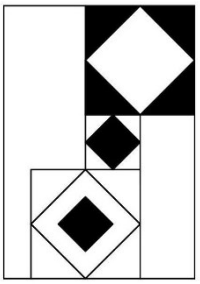
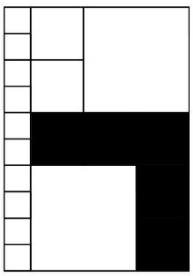


Figure 4.25: S1's new rule shows the relationship between a quadrangle and the one twice its size that prompts another rule: a quadrangle within a bigger quadrangle. The picture on the right demonstrates how this rule is used iteratively in the design.

The entire work is rich in exploring the possibilities of the formal relations indicated in the dialogue. It also shows how the learner is first accountable to herself by being in control of the spatial relationships of a design employing shape rules. In one case, Computation 5 in her composition was interpreted as two squares that relate by recurringly increasing the size of the square elements and reproducing a square within a square (Figure 4.23). Exemplified in the case of S1, the assumption was that students learnt to apply visual rules and, in the applications, acknowledged emerging shapes and rules, which they used to consolidate the form relations, they started their explorations with.

Table 4.5 : A protocol extract from Phase 2 (coding for the roles is P: pair, S: student, C: client).

Student	Protocol	Composition
P1S1	[The design has started with small triangles and squares, and by contrast, they form other big squares and triangles] [These two bigger squares relate by the contrast in the smaller pieces]	
P2S1	[The small square is composed by the contrast of white and black triangles] [There are four triangles, which form this big square and this central square we perceive as white area] [… anywhere you look you perceive a square]	
	[We can perceive a square, and another bigger square, scaled one. It has scaling that we can perceive it easily] [… this big square is formed of four small ones]	
P1S1	[It has some geometrical rules. It has another rule too]	
P2C1	[I am not convinced yet, is there any rule to re-produce it?]	
P1S2	[…this bigger module is repeated two times]	
P2S1	[We have repeating elements, the small squares]	
P2S1	[…the small square is the unit of measurement to place the other pieces together] [… you can see some reference lines, they run diagonally, and they help position and form other figures]	
P2S2	[They give reference to create another shape (pointing to the lines running diagonally)]	

4.4.4 Tracing attitudes of accountability

Three months following Phase 1, further experimental steps have been undertaken to validate attitudes that students have purportedly learned in Phase 1 at the end of the semester. Two groups for Phase 2 and four pairs for the next Phase 3 were arranged for the participants. The recorded protocols of the participants' talks are evaluated to observe how the individuals respond to the designing process of their fellow. During

this study, collaboration in groups/pairs benefits conversing and verbalizing the activity spontaneously among participants. Moreover, talking stimulated students to explain their reasoning towards being accountable to their fellow.

The design episode of Phase 2 comprised of a brief role-play. The participants were required to persuade another fellow in the role of the "customer" to buy the two-dimensional design created by S1 in Phase 1. They were invited to argue on the formal properties of the composition and to articulate their thinking in a group. The use of shape rules was not emphasized. The parsing of the protocol for both teams is straightforward, as the experiment was of short duration. The focus is exclusively on the dialogue chunks in which the participants refer to the compositional relationship between the components and the reference system.

Phase 3 was followed by the last design assignment. This time the procedure was reversed: Participants were encouraged to recognize relationships of a final design at Phase 2; in the consecutive step, participants were required to collaborate on applying what they saw as a formal relationship in a new design. The design challenge was the same as in Phase 1. Table 4.5 provides an excerpt from Phase 2 protocols and the potential visual rules derived from discussions of Phase 3 (Tables 4.6).

4.4.4.1 Some observations

Some findings of the design experiment are as follows: the design was arranged by most participants based on a grid (3 out of 4 pairs: one of the participants who was not present in Phase 1 and not read the dialogue, did not employ a grid as a referential system). The students employed the forms as the measuring unit or grid unit and referenced this element in protocols (refer to Table 4.5).

Most participants identified emerging squares of varied sizes based on the relationship between the given forms and the new ones. (Two of the students who did not engage earlier in Phase 2 could not manage to define emerging squares in Phase 3). In all examples mentioned, the participant's experience with the dialogue influences their way of working.

During Phase 1, only one student created shape rules for the relations described in the conversation and how the forms are related. Most participants have verbally established connections between the forms. During the discussion of rules of relationships at Phase 3, instead of pointing at forms or tacitly composing, the students

used rules as a means of communication. Whenever a participant declared a rule, most fellows knew how to continue the composition. When encouraged to talk, it seems that students utilized their knowledge of visual rules.

Table 4.6 : Selection from protocols in Phase 3.

Theme	Student	Protocol
Grid	P3S1	[Let us start with a square so that we form a grid]
	P4S1	[Let us start with this grid over here: there are these diagonal lines but also straight lines]
	P6S1	[I think with these we have like a grid]
Unit	P3S2	[Let us measure the canvas dimension in terms of the chosen square. It is almost 5 to 3 squares]
	P5S1	[I think we should start with one of the pieces for reference]
	P6S1	[I think we can use it as a module]
Defining a square	P5S1	[We want to define by juxtaposition squares via triangles]
	P6S1	[…add a small triangle on the white area so that it forms our unit of measurement, the square]
	P3S1	[…as the sides (of square and small triangle) are equal we can create another square]
	P6S1	[I think we may achieve a bigger square through the combination of these triangles and the small square...my aim is to create a reverse square; this is black, and this is white through juxtaposition]
Defining shape relation	P6S1	[We should create a relationship between this square and these small triangles because as we see the side of the triangle is equal to the side of the square]
	P3S1	[It would be better if we use another shape, which takes reference from this diagonal]
		[…we may repeat the large, composed square but shifted towards the edge of the paper]
		[I think it should have one-to-whole relationship and I do not see it here]

At the beginning of the study, a learning objective for design attitudes in foundation studios was posited, in using references and establishing relations of various elements of design in connection with accountability. Accountability for performance throughout a design process is viewed as an attitude at the level of each student. Accountability throughout a design process relates directly to thinking and combining it with validating arguments or reasons.

Meno's central topic is whether virtue can be taught. In this regard, Socrates conversed with a boy who, by reasoning with the shapes sketched on the ground, in turn, understands the Pythagorean theorem. The study shows that visual rules and computations describe the process of thinking in studio studies and leads the learner

to a knowledge of relational design thinking by drawing similarities to the visual reasoning Socrates conducted the interlocutor.

In the studies conducted, the design elements given to the students (Figure 4.18) were suggestive of certain form relations. Their sides had the ratio of √2:1 just as the lines drawn on the ground in Meno. This proportional relation is sought, iterated, and utilized in the works of all students who also answered to the directive that they create new squares of different sizes. To perceive and define an emerging square out of the restrictions of the given shapes, it demanded students to understand a series of relations between shapes.

In one sense, each student created a variation of the Meno dialog, and the design brief was primarily used as a guide. In a design study, the distinction is that the products do not reveal the mathematical relationship, but many instances of the same relationship in which the squares and triangles of varied sizes and orientations. The difference created by each participant attests to his knowledge of the relationship and its variants. A further competence in their knowledge of relational design thinking is the control they can or cannot use in producing these variants.

The visual rules for every participant's work illustrate that the mathematical relationship may be depicted in many cases. In a pragmatic approach, a student can concentrate on triangular relationships while the other can concentrate on a couple or a square based on the visual arrangement. The emerging square of a new size from the hypotenuse or the diagonal is the common denominator of all rules in this study episode. This is inherent in the brief and in almost all the rules. The students were already familiar with visual rules. They were able to compare alternative approaches to the same occurrence and variations as they expressed their thinking using visual rules. Eight out of ten students based their compositions on the different grid organizations.

Preliminary inquiries indicated that participants were conscious of the relationship between shapes and the cluster of forms in individual works and among works across the group. In the first place, they accounted for the designs by formalizing their thinking in line with their dialog interpretations. In this way, they could keep track of their actions, reflect on the possible outcomes, and understand what is going on.

By drawing a comparison from Meno, a student remarked on this circumstance. Like Meno, they follow a similar way of thinking: it begins with a design requirement and then a hypothesis. They realize that the presumption may not be correct in the following phases and return to a previous step. This procedure continues until a solution is reached.

Accountability also enables students to have transparency and make the process visible, creating room for sharing knowledge and understanding in the studio setting. The study indicates that students are already developing a habit of using visual rules to communicate and convey design judgments with their peers in three months. However, the evaluation of the impact of these collaborative activities in improving personal attitudes requires further study over extended periods and in many contexts.

4.4.4.2 A survey on studio learning

The design exercise based on the Meno dialogue was performed for the entire semester of Fall 2016 in a basic design studio, including forty beginner students as opposed to a study series of students in the second year. The studio's aim again has been to incorporate computational formalisms into studio education methodology and to evaluate the impact of designers and collaborators in promoting attitudes of accountability. These students were introduced to visual rules for the first time, differently from the second-year students.

The design tasks are arranged according to (1) individual work and (2) pair and share. In the first method, students are allowed to establish their criteria for potential connections based on class discourses about formal concepts. Visual guidelines are created and enforced by self-imposed limitations for learners to add to, remove or change specific design arrangements.

The second mode is characterized by exclusive collaborative design processes. Students interchange their designs to interpret the possible design actions of their respective fellows by use of visual rules. Students work separately via negotiation and monitoring of the rules of relationships the fellow student uses. Employing this method, participants will think comparatively about the group and individual processes regarding what rules they have been using and how their own rules have evolved in a succession of tasks.

In response to post-event feedback, students were invited to consider how their understanding changed during the learning experience. Referring to the first part of the questionnaire, students were asked to write down their reflections on how their thinking was before and how it has changed after the course. The data analysis procedure consists of identifying statements of the students, which refer to the possible dimensions of attitude construct. In a second step, the statements are grouped according to their commonalities and labeled with an initial coding. The analytical process of the initial coding resulted into separate themes such as: understanding/meaning making, accountability, sharing in collaborative practices, transfer of knowledge, change in perspective and organization/management (skill). The focus was only on those categories, which are related with the learning objective as stated in this study. The procedure of identifying codes and assembling them into separate themes is presented in Table 4.7.

The data analyzed from the questionnaire provides evidence of a general awareness among students with reference to the pedagogical method followed. Most of them are able to talk about the relational feature of design thinking, similar to the group of students who performed in Phases 1, 2, and 3. However, the students who were exposed for a whole term to visual rules, even if it was their first exposure to them, report a higher level of accountability: “The most valuable aspect of this course is being reasonable (giving a reason for every action that I do)”. It is surprising to see that students can talk about how their understanding has increased by externalizing their design reasoning through visual rules and reflecting on what they have done. Reflections are often seen as the internal processes of isolated individuals; however, students report on developing awareness by comparing and reflecting on their peers. An indispensable part of this awareness forms by sharing.

Table 4.7 : The categorization procedure includes arranging the results of the open-ended questions into topics.

Theme	Initial coding	Student Report Statements
Accountability	relational design thinking	[You need to think about the relations that your design represents, the reason why it was created in that way.]
	thinking about the consequences of an action	[I used to think that background for example, or the way how we put something somewhere was not so important /But now I think, and I have learned that even background has its own meaning.]
	know-why	[My way of thinking has changed a lot in terms of "if I do this what's next"]
		[Whenever I start a design task, I always ask myself, why?]
	reasoning based on arguments	[The most valuable aspect of this course is being reasonable (giving a reason for every action that I do) and being organized.]
		[Also, a very valuable aspect of this course is teaching us that all our proposals should be based on concrete arguments.]
Understanding/Meaning making	visual reasoning	[I thought that we were doing something meaningless but now I can understand and can read visually what we have done.]
	reflecting on and learning from own mistakes	[I am glad that even if my work is not classified as a good work, I understand my mistakes and how to improve them.]
	learning by doing	[We can learn by practice and by reflecting on our assignment and our mistakes. By passing time I believe that we will understand what we have learned.]
	understanding by externalizing the reasoning through visual rules	[I used to think there was not needed to explain the rules I have used in my composition/ but now I think that visual rules are important and help us a lot.]
		[Using visual rules in terms of relationships is a valuable way to understand what we do have in our minds and to improve ideas that we have for each composition.]
Sharing in Collaborative Practices	learning by sharing with peers	[I consider the work with my friends as a good way to learn more. I can easily compare works with each other. I can easily evaluate my work and reflect on the things I have done and how can I improve it.]
	awareness by comparing with peers	[We can learn by practice and by reflecting on our assignment and mistakes. By passing time I believe that we will understand what we have learned.]
	reflecting on personal and peer work	[Even others' failures and achievements affect my works.]
		[Working in pair offers more design possibilities.]
		[Working in groups, which mean more ideas for different assignments.]

5. CONCLUSIONS

The conclusions of this thesis are three layered. The thesis firstly argues that attitudes are a necessary learning competence in architectural design curricula to overcome the technocratic character of designers stemming from the digital age. The second layer of argument focuses on attitudes of accountability to support transparent reasoning and interaction for cultivating socially conscious designers. Last, computational design in the form of visual computing, that considers seeing as a way of thinking, is introduced as the recent technology of how learners reflect for implanting attitudes of accountability among them. This chapter overviews the original contribution of the research by delineating the main arguments of each earlier chapter. It follows with recommendations and suggestions on potential future work.

The multidimensional attitude construct was discussed in Chapter 3. The references spanned a literature across five domains which accommodate attitudes as relevant to the context of architectural design education. These domains are higher education, design thinking, philosophy, social psychology, and sociology. The connotations in the first column of Table 5.1 are the terms used interchangeably for or with attitudes in the various literature, as illustrated in Chapter 3. The center column counts the different values I came across as constituents of desired attitudes in these domains. These show the breadth of the terminology, and accountability is just one on which I further dwell. Terms overlap or coincide. Openness, sharing, transparency, and many more resonate with accountability. Based on the literature, I could link relative terms in situating accountability as an attitude in design education.

In a holistic view, learning is a synthesis of knowledge, aptitudes, and attitudes. Many national frameworks that align with the European Qualifications Framework point to the importance of addressing the cultivation of dispositions and skill acquisition. While there exists explicitness in higher education about the knowledge and skills to be achieved, explicitness about attitudes has been less developed. It is challenging to distinguish clearly between knowledge, skills, and attitudes as they are not mutually exclusive entities. The relationship between the three learning categories depends on the character of the curriculum model and the domain. Additionally, different terms

and categories are used interchangeably with attitudes in the higher education literature, as illustrated in Table 5.1.

Table 5.1: Classification of terminology for delineating attitudes into domains, connotations, and attitudinal values.

Attitude Connotations	Attitudinal Values	Attitude Domains
affective domain	accountability	higher education
attributes	compassion	
competence/competency	collective action	design thinking
conative domain	curiosity	
dispositions	democracy	philosophy
design attitude	empathy	
habits of mind	equality	social psychology
habitus	environmental responsibility	
habitudes	ethical behavior	sociology
learning outcomes	ethical sensitivity	
set of heuristics	friendliness	
	honesty	
	inclusivity	
	integrity	
	mutual respect	
	openness	
	resilience	
	respect for human rights	
	sharing	
	social responsibility	
	sustainability	
	tolerance	
	transparency of process	

Attitudes were evaluated from two main epistemological perspectives positioned on the opposite poles of a continuum: the behaviorist and the pragmatist/social constructivist approach. In this study, attitudes were evaluated for a process-driven curriculum where every learner develops personal learning experiences. Accordingly, learning outcomes focus on the process of learning rather than results; they are open to interpretation, which limits their measurability. Hence, attitudes stand for disputable competence in terms of addressing and assessing them.

As addressed in this thesis, attitudes have ethical connotations as it has to do with respect for one's work and the work of others. It allows for open learning processes to receive feedback and engage in collaborative practices. The process starts with

developing self-awareness about one's knowledge and how others, including multi-perspectives, perceive that. Thinking about or reflecting on one's reasoning provided a perspective on how to structure the empirical work of this study. Labeled also as metacognition, reflective thinking stands as a condition for learning and changing attitudes, as attitudes were further articulated from the social psychology perspective. Last, as treated in the design studies, professional attitudes fall short of addressing the social aspect of the designing, with some exceptions from the design attitude literature.

5.1 Why Attitudes Matter for Design

Studying in an architecture school, or being an architect, has long been associated with developing an aptitude in drawing. Since the Italian Renaissance period, paper-based drawing has prevailed the skill set of design professionals. The Renaissance defined architecture as an immaterial practice because the design process was conceived in the mind of the designer. The architectural drawing stood as the creative expression of the individual designer. The new intellectual status of the architect introduced a different perception towards the profession, characterized by the individualistic (egocentric) attitude. The designer as the lone genius has been the unquestionable core of the design process for centuries. Nowadays, promoted under the label of the "starchitects," architects have become part of the celebrity culture.

A similar "solipsism" towards the digital in architecture is witnessed in the last decades at the cost of risking the humanistic dimension of design. The recent technologies in architectural culture seem to have made justice to the attitudes attending to the "black box" of individual creativity. With an inward-looking emphasis on the design process, digital technologies have opened and brought some clarity to the black box that is often described solely in terms of its input and output. Yet, computational approaches to design have reduced the architectural discourse to issues of instrumentality, like efficiency in production and innovation in formal expression. Architecture schools are becoming ever more vocational. Alongside the technical aptitudes, it is imperative to foster attitudes among learners for a critical engagement with technologies. Attitudes complement and amplify a designer's technical skills, enabling good communication and collaboration in practice. Cultivating a diverse set of human-centric skills, i.e., attitudes come on top of other technical or digital aptitudes to propel effective learners and professionals beyond technical competence. Students are not taught explicitly but

are expected to acquire attitudes along the way. Now that professionals and higher education institutions are settling to a post-pandemic context, among the human skills necessary to keep the workforce together, attitudes of accountability are crucial than ever to sustain the eroding culture of design practice or the studio. In that respect, attitudes are crucial in adapting to unknown and changing contexts of the architect's engagement to the profession. The COVID-19 pandemic has caught all professions and higher education institutions off guard in managing the workforce online. Rather than a successful engagement with the technology in terms of immediacy, attitudes and soft skills are imperative in uncertain situations to run things forward. The culture of accountability has been crucial for the remote communication and collaboration via digital tools and platforms.

From a design computing perspective, there are already studies exploring the use and integration of visual rules and the shape grammar formalism to the first-year design education, but this study takes the discussion on a different level. In the experimental studies conducted with the students, this research used analog tools that might be one of the following: visual, spatial, or even material rules focusing not only on the outcome but rather on how this kind of approach develops certain attitudes.

The argument of this research builds upon and highlights crucial dialectics of the instrumentality of computing in design. First, it is the issue of accountability in terms of the relationship between computing or digital instruments and their application in design: accountability of integrating the digital instrumentality in the design process. The contribution of this research is that it moves away from the technical specificity of the digital tools and focuses on the impact of those tools on a human scale. Yet the impact does not necessarily have negative connotations. Along with the critical perspective this study brings to the computational approaches to design, it is the digital instrumentality per se, used here as a method or tool, to make accountable the designers and their processes.

Technical-skill-building is notoriously associated with technological hardware and how to operate them. In this study I subscribed to the Deweyan notion of technology defined as learning by inquiry, later brought to attention by Buchanan (1992). Different from what is widely regarded in today's philosophy of technology, for Dewey, it is an art of experimental thinking rather than knowledge of how to produce and utilize artifacts or the things themselves. Technology is inaccurately associated with a single

product-hardware that results from experimental thinking, but the art that lies behind and serves as the foundation for producing other sorts of products is often overlooked.

From this Deweyan perspective on technology, design is the technology of how one thinks because of its inquiry-based and experiential nature, as the word itself implies. Considering the roots of the word (*techne* and *logos*), technology stands for the practical application or creative expression of an art, craft, or skill. Accordingly, design education provides a ground to introduce higher-order thinking beyond aptitudes, due to its inquiry and experiential-based nature.

Similarly, computation and design are both conceived as reasoning processes, complementing one-another, hence the corollary: "computation as design" (Stiny, 2001) and "design as computation" (Özkar, 2005). A general kind of computation, it is not limited to the use of computers only. Therefore, it is important to distinguish that computation from computerization. Computation makes the design process explicit rather than automated. Computation is a term that differs from computerization. Computerization is about the digitization and automation of processes in the digital medium, or the computer. Whereas computation is exploratory in nature and involves reasoning processes made explicit through rules. For this reason, computation does not necessarily have to be addressed through computers. Second, various features of design may be delineated through computation, mostly visual computation. Visual manifestations of forms in a design cannot be separated from the underlying processes generating them. Computational design, then, is not to be understood as a technical skill but as an attitude of exposing the actions in the process.

The shift of focus from computerization to computation is crucial in this study because it emphasizes the capacity of computational methods as a tool for developing self-consciousness and trans-personal consciousness as well, making the design process and the product more transparent. Hence, design is all about accountability, which is either implicit or implicated in the design act, the process, the tools, and the materials used. Otherwise, the design acts would be judged from an aesthetic perspective only which could be an infinite and unquestionable process.

While the pandemic had a huge effect on designers, it also highlighted the designer's role as bound to social responsibility, beyond creativity only. In response to many challenges posed by the COVID-19, designers in collaboration with scientists are

making use of the technology to develop self-sanitizing materials for surfaces, UV cleaning products, designing open-source face shields or handwashing units to make it an experience for children to engage to. Although these examples are design solutions to obvious design problems, seen in a different light, such collective actions have an impact in terms of the social empathetic practices. The challenges posed by the pandemic might be an emerging opportunity for the design community to alter the professional landscape in terms of their relational accountability to the society.

The same perspective could extend to artistic practices as well; as the boundaries between art and design are becoming more blurred, one cannot talk of aesthetic accountability only. Social accountability in art might sound paradoxical as its perception is subjective to the viewer. However, art as well is responding to the increasing dominance of science and technology. The design biennales of recent years are promoting the collaboration of what might seem as two opposite poles i.e., art and science. Practicing art is not about a personal process only but also about social contribution, ethical decisions and making things visible.

5.2 Situating Design Technologies in the Basic Design Studio for Reflective Attitudes

The basic design educational model served as a venue to weave reflective attitudes with the other first-year design competencies. The contribution of this study is a reinterpretation of the foundation studio pedagogy from a computational perspective. Framing visual computing as a new design technology becomes the means to reflect, communicate, share, and collaborate in the collaborative learning environment. Analog computational tools like visual rules scaffold students' thought and production processes.

Introducing the design technology to externalize reasoning brings a new meaning to computation and design education. Computation is not a burden but the means to reflect, share, compare, and alter, in the transcending and empowering learning experience of the basic design studio. The basic design studio is an inclusive environment where active individuals are offered tools and opportunities to articulate their thought and production processes. It is imperative to develop an awareness of the process and or before developing a design fluency competence.

The motivation behind this thesis was to build a case in architectural education for the methodological impact of computation on approaching design as a social act of creation. The values of accountability and sharing were framed concerning transparent processes and the social practices of designing. Alongside a technical aptitude, the student reflects and develops personal values during the experience. Learning design is about training judgment. How effort and exertion train judgment is both personal and collective, making the studio the pragmatic and, at the same time, creative design learning environment it is. These reflective environments foster attitudes. Moreover, the design studio is the attitude-forming environment, as students are socialized in the profession and embark on attitudes and values.

The empirical support of these issues was addressed in three instances in Chapter 4: a. reflecting and accounting with a shared design language, b. the impact of process sharing on accountability, and c. accountability in relational design thinking. From the context of shape grammars, visual rules stand as a design language that document thought processes and support beginning designers in developing a sense of accountability for their design thinking.

Accountability is reasoning in a design process, coupled with validating arguments. This approach was exemplified regarding the Socratic dialogue, Meno. Drawing parallels to the visual reasoning in the dialogue, students enacted a version of the dialogue by producing multiple instances of the same relation, guiding them towards an understanding of relational design thinking. The reasoning process was shared and internalized in a collaborative learning setting, structured as reflection-in-action, -on-action, and reflection on reflection-on-action. In the final part, evidence for accountability is sought by analyzing students' attitudes and how they appraise the processes in their reflections by employing the linguistic analysis technique. The visual rules reported in a written format served as the medium of analysis.

Shape grammars are a formal, generative design system relying on visual computation that consists of shape rules. Shape rules apply to shapes based on their parametric or geometric attributes. The recursive application of a shape rule is a computation with a design output—the variations in the sequence of rule application yield multiplicity of designs. As shape rules perform entirely on visual computations, they provide a constructive understanding of the basic design knowledge transmitted in the studio.

The pedagogy of the first-year architectural design studio relies on abstraction as an intellectual and practical method of inquiry into design. In many foundation studios, abstract forms are tools to facilitate the judgement process by keeping the focus not on form itself but on exploring the relations between forms with minimal number of features. Comparisons of form involved direct attention to details and specific properties of shapes to draw out relationships. Defining form relations consisted of perceiving visual parts and wholes and relating them at different levels of complexity. In their regular run of first-year design studio, the volunteering students in the study already alter, transform, combine, and define relationships between shapes in their designs, organizations, or compositions. They lacked an awareness of how the design knowledge is conveyed, noted as the learner's paradox.

Introducing visual rules in the studio scaffolded the communication between students. They were encouraged to develop their languages of design by defining rules of relationships between the shapes. Shape rules come in the format of Shape A → Shape B. Participant students of the study failed to "technically" write up or draw exact rules. However, referring to students' reports, I deliberately classified and accepted the representations of visual relations as a sufficient manifestation of rules. Identifying a series of spatial relations and corresponding rules becomes instrumental for the external interpretation of actions. The documented shape relations were integrated into the design process while being open source for every other peer to learn from.

Although the study participants were able to identify and define rules of how design elements relate, they faced difficulties in applying visual rules in new designs. The design episodes depicted in Chapter 4 illustrate how students tend to vary progressively from the analyzed to the applied compositions while developing an awareness of changing rules in personal design processes. Students were free to make up rules based on their own experience. Rules do not guide them through designing in a certain way but allow them to talk explicitly about the particular ways they hypothesize in designing. Because they are subjective and personalized, the visual rules attest to the attitudes practiced during the process of reflection.

This study is qualitative research on attitudes in design learning. It does not propose a "one size fits all" model as the study findings relate to a few conditions. It was limited by the information students' documentation conveyed. As students participated voluntarily, it was an extracurricular engagement for them. Their effort in doing and

redoing the compositions diminished as the exercises proceeded, evident in the lack of unity and complexity in their compositions.

Moreover, most of the students did not fully grasp the potential of visual rules quickly and did not knowingly follow the instructions. They were able to identify only a limited number of visual rules. Further research, provided with more extended periods of engaging with the participants, should ideally produce and analyze more rules and better-quality visual data.

Another issue is the context of the study in terms of region, language, and studio setting. The data interpretation was partially based on students' written reflections. The language bias might have affected their mode of expression, as English is their second language. All the participating students were Albanians. Future work might generate interesting results if the study includes variations and comparative analysis regarding students' backgrounds, culture, and education.

The pedagogical method followed in the studio setting of the study relies on a sequence of abstract design assignments, where students exert judgment on defining relationships at different design orders, between two or three-dimensional shapes. The student's motivation and effort decrease as the assignments vary little by adding a design input in each consecutive assignment. Future research might opt for alienation of the students learning by shifting interchangeably between different media. One approach is to enhance the constraints of the visual medium by including other design inputs like the haptic feedback while dealing with different materials. Another approach is to switch from abstract to real context design problems and back to abstract organizations again. In this way, students would situate the relational thinking experienced in basic design to other media. Switching between different media might play a role in students' motivation and engagement in their learning process. In this study, students paired and shared their abstract two-dimensional designs for reflection and collaboration in a controlled way. It would be interesting to assess attitudes and how students are held accountable while making a real full-scale model in a collaborative process.

The last drawback is the limited number of participants; a larger sample might have produced more visual materials to assess and yielded other results. Nevertheless, monitoring lone-designers or a small team's design interaction are among the common

methods followed in design studies to assess the socio-cognitive dimension of design processes. In this respect, an important contribution of this research is highlighting the meta-cognitive aspect of the design process that is less known and addressed in the design studies literature. Metacognition refers to monitoring processes that assess cognition and strategies, i.e., cognition on generating cognition. The perspective on metacognition, as introduced in this thesis, is grounded in Schön's seminal work. Accordingly, this study addresses the metacognitive process in three levels: reflection-in-action (reasoning), reflection-on-action (judgment) and reflection on (reflection-on-action) (reasoning).

5.3 Attitudes of Accountability for a Critical Engagement with Design Technology

In this study, I first gave an overview of the notion of accountability which denotes the exchange of reasoning for conduct. Accountability was explored in a tripartite method: conceptual, contextual, and empirical exploration. The conceptual exploration highlighted that there are varying and disconnected accounts on accountability. It does not surface as an explicit issue in design activity, but it is interwoven with designers' on-going judgments and actions. Accountability is about making thinking and actions, visible and observable, so that reflection on self and in relation to others takes place. Accountability was framed in terms of openness and transparency, usually in the form of a dialogue. Yet, asymmetrical power relationships could inhibit the talk. This served as a starting point for addressing design accountability (in action/interaction). Followed by the contextual exploration, I delineated three contexts in which accountability was addressed as a quintessential attitude for design practice and education, and how these are supported by computation.

The penultimate section, the empirical exploration, set out a case of current efforts on how attitudes of accountability are cultivated among early architectural design education competencies, considering Schön's model of reflection-in action. Finally, computational design was argued to be a reflection tool in early design education, contributing to process sharing and thus accountability. Embracing "design as computation" (Stiny, 2001) and "computation as design" (Özkar, 2005), the externalization of the process is in service of a social point of interest. It evokes accountability and sharing.

To foster ethical practices, there is an increasing need to cultivate and assess attitudes in architectural design education, like knowledge and skills. This thesis focused on the accountability for design reasoning as an attitude for the design studio considered from the light of higher education, social psychology, and design studies. Accountability is a tacit competency that is not easy to address and assess. Layered as affective, cognitive, and behavioral, attitudes are complex ways in which individuals respond promptly to changing contexts. Studying the means of reflection on individual and collective reasoning in design offers a perspective on how to structure future empirical work on attitudes in the studio.

As design is more and more practiced as a social act of creation in the 21st century, we desired to reveal the methodological impact of computational design thinking on accountability. Adopting design as computation and computation as design, the externalization of the design reasoning process is at the service of the social acts of designing. A collaborative learning environment provides greater opportunities for self and collective reflection and ultimately accountability. First, the externalization of one's design reasoning brings some transparency to the process. Second, this transparency allows oneself and others to trace reasonings and actions. Finally, sharing one's knowledge and reasoning initiates reflections for further actions. Externalizing, sharing, and reflection motivate accountable actions in the design environment.

In attempts to validate this point, it was referred to the use of analogue computational tools, i.e., shape rules, in a first-year architectural design studio and inquired about reflective thinking to understand whether making visible the divergence and convergence of students' reflections provide a ground for partaking and justifying their actions. The reference framework for accountability derived from three forms of it -- one, in collective ac on enabled by technology, two, through form itself as the manifestation of design, and three, in learning with peers. It was through protocol analysis how visual computation can be a tool for embodying these forms of accountability in design education. More long-term evidence is needed to assess the impact of computational devices on accountable design attitudes in learning environments through externalizing thought processes as well as how this matches with the creativity that is a key feature of design studios. The formalism of visual computation serves the mental constructs of the learners and represent their visual reasoning in design. As such, computation becomes a tool of sharing, comparing,

reflecting, and changing that transcends and strengthens the learning experience in design studio settings, especially in the first years.

The openness of visual computing in basic design not only serves to document form relations but also helps beginning designers to develop an understanding of what design thinking entails for communication and collaboration. As such, computational methods allow for open design education in support of democratic studio environments, where “openness” is read in different layers: an open design process, open to peer review, open to collaboration, open to sharing, and open to embrace others’ views. Such attitudes are not only operative for the design process, but they also inform a novice designer’s conduct towards colleagues in the design process. This study demonstrated that computation in early design education is supportive in instilling desired attitudes such as knowledge sharing and a consequent accountability. It showed that even a simple rule-based approach to design incites general attitudes among learners in a short term.

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