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Teaching to transfer causal layered analysis from futures thinking to design thinking

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We live in exponentially changing worlds. Design educators are challenged to teach new design methods to productively engage with society's ongoing problems such as the Sustainable Development Goals, the unfolding climate disaster, zero-carbon lifestyles, circular economies, nuclear disarmament, etc. Such societal-level problems require both short-term design action and strategic long-term vision goal alignments. How might design educators teach new design methods effectively and efficiently within already packed design education curriculums? In this paper, I describe a required design futures course that teaches an experimental form of design, called Dexign Futures, it merges design thinking with futures thinking. One often unstated goal of teaching new design methods is to enable students to transfer such knowledge to other design courses, and, ultimately, to their professional practice. The futures thinking method, Causal Layered Analysis (CLA) is the focus of this paper. Prior research on Dexign Futures, made clear that with a "Personal Futures CLA'' assignment, only 19.8% of design students could articulate how the Futures Thinking method CLA related to future design methods and practice. In this paper, I describe a new way to teach CLA called "Studio Project CLA"; it more than tripled the number of undergraduate design students (62%) who described applications of CLA to their design practice. I posit that transfer of knowledge mechanisms likely explain observed performance gains. I hypothesize key insights relevant for design educators to create design exercises for undergraduate design students that likely facilitate knowledge transfer from futures thinking methods into design practice.

Keywords: design futures; causal layered analysis; design pedagogy; knowledge transfer; dexign futures

1 Introduction

We live in exciting, interesting, challenging, yet confusing times. What is an engaged design educator to do? Consider contrasting global challenges such as the: war in Ukraine and the push for global nuclear disarmament; unfolding Climate Disaster, and Extinction Rebellion movement (Farrell, Green, Knights, & Skeaping, 2019); fossil-fuel disinformation (e.g., Mulvey & Shulman, 2015) and proposals

for zero-carbon life by year 2050 (e.g., Gates, 2021; Doerr & Panchadsaram, 2021; Hawken, 2021; Griffith, 2021; Godin, 2022), and so forth. Or the optimistic news about climate change exemplified by TED: countdown talks (2019) compared to the slew of IPCC reports on climate change describing stark realities (IPCC, 2022). Traditional design methods are insufficient for such global and local challenges (e.g., Ceschin & Gaziulusoy, 2020).

Design Thinking focused on short-term gains is often associated with known societal problems such as consumerism, resource depletion, income inequality, and environmental devastation. Societal challenges such as zero-carbon transitions require other design methods and processes aligned with long-term worldviews, values, and stories. The temporal design challenge is to link short-term design actions to long-term sustainable vision goals. In other words, merging Design and Futures methods can help to address societal challenges such as zero-carbon transitions. One might wonder how design educators can integrate Futures Thinking methods into design education so that students can learn to address design opportunities strategically. Furthermore, design educators may wonder how new design methods can be taught so they transfer to professional practice? Next, I will describe some initiatives to teach Futures in K-12 education.

1.1 Teaching futures in K-12 and beyond

Why might Futures Thinking help designers to navigate a rapidly changing professional design landscape? The accelerating pace of change experienced requires younger generations to learn to shape and inhabit futures in their lifetimes (Toffler, 1970). Teaching futures literacy prepares students to engage with worlds that await them as adults (e.g., Bishop & Strong, 2010). There is a long tradition linked to teaching futures literacy to broader populations (e.g., Slaughter, 2008; Riel, 2018; Abdullah, 2022; Häggström & Schmidt, 2021). Jerome Glenn advocated for "futurising" teaching practice rather than adding separate futures courses to school curriculums (Glenn, 1972). Next, I describe some initiatives to teach design futures in universities.

1.2 Teaching futures to designers at universities

Increasing global enthusiasm for Design Futures is evidenced by the growing number of Futures-related design courses and approaches worldwide. Teaching futures to designers in universities worldwide varies by design futures traditions such as Critical Design (Dunne, 1999; Raby, 2001), Design Fiction (Sterling, 2005), Speculative Design (Dunne & Raby, 2013), Discursive Design (Tharp & Tharp, 2019), and Experiential Futures (Candy, 2010). More recently, other notable projects combining design and futures include Speculative Edu[1] (Mitrović, Auger, Hanna, & Helgason, 2021) and Fuel4design[2] (Morrison, Celi, & Cleriès, 2021).

This paper describes a Design Futures course called *Dexign Futures*. *Dexign* indicates an emergent and experimental form of design that combines Futures Thinking methods and Design Thinking methods.[3] Starting in spring 2022, the *Dexign Futures* course was taught to first-year undergraduate students as a required Design Studies course.[4] This paper compares first-year students to third-year

[1] https://speculativeedu.eu/

[2] http://www.fuel4design.org/

[3] The term "Dexign" was coined by Arnold Wasserman in 2013 while co-teaching the "Dexign the Future" course with Peter Scupelli. Dexign Futures methods emerge by embedding Futures Thinking into design processes and methods.

[4] Dexign Futures was developed at the School of Design at Carnegie Mellon University to provide students with new design methods to address societal-level challenges in the 21st century (e.g., climate emergency, zero-carbon transitions,

undergraduate design students. In the next section, I describe CLA and why *Futures Thinking* methods such as Causal Layered Analysis (CLA) should be taught to university level design students.

1.3 What is CLA, and why Teach CLA to design students?

Causal Layered Analysis (CLA) is a futures thinking method developed by futurist Sohail Inayatullah. CLA provides the intellectual scaffolding allowing one to notice how behavior links to social systems and infrastructure, worldviews, and myths/metaphors (Inayatullah, 1998; 2004; 2009; Inayatullah & Milojevic, 2015; Inayatullah, Mercer, Milojevic', & Sweney, 2022). CLA draws from different epistemologies from poststructuralism, macrohistory, and postcolonial multicultural theory (Inayatullah, 2004; 2009). The power of CLA lies in making explicit such diverse perspectives. In addition, the CLA method allows analysis of current situations and exploration of future scenarios.

- Litany/Behaviour is the most visible aspect of an issue, the quantitative data and trends, problems, often exaggerated by the news media. The litany typically involves easily observed behaviour and data.
- Social Causes/Systems/Infrastructures The second level involves a systems point of view. What infrastructures support and enable the behaviours observed in the litany? Quantitative data is often interpreted by experts as social causes, including economic, cultural, political and historical factors.
- Discourse/Worldview The third deeper level of analysis regards the structure and the supporting discourse/worldview that provides cultural legitimacy. Different lenses frame how people understand an issue (e.g., economic, religious, cultural).
- Myth/metaphor The fourth layer of analysis involves metaphor or myth. It provides an emotional level of understanding to the worldview under inquiry. Often expressed as "deep stories, collective archetypes, or unconscious dimensions of the problem or the paradox" (Inayatullah, 1998; 2004; Inayatullah et al., 2009; 2015; 2022).

CLA helps designers understand the structure of reality where they operate and provides scaffolding to find strategic design opportunities. CLA is beneficial for societal design challenges that require aligned short-term design action with long-term vision goals. CLA analysis of the current state and the desired long-term future state can help designers identify and frame design opportunities at the behavior level, infrastructure level, worldview level, and myths/metaphor levels. Next, I describe knowledge transfer challenges.

1.4 Transfer of Futures Thinking Learning into design processes

One of the premises of design education is to train students for professional practice. Design learning through studio-related activities is characterised by five factors: co-location, learning-by-doing,

sustainable development goals). The Dexign Futures course first launched in 2016 was a required 15-week course for all third-year design students (see Scupelli & Brooks, 2018). In 2018, a different version of Futures was taught (see Scupelli, Candy, & Brooks, 2019). From 2019 onwards the Dexign Futures course was redesigned to be a 7-week course called Futures 1 when taught as a required course or an elective called Dexign Futures. I have written about Dexign Futures course content evolution and pedagogy elsewhere (Scupelli, Wasserman, & Brooks 2016; Scupelli & Brooks 2018; Scupelli, Candy, & Brooks, 2019) and teaching Dexign Futures in different settings such as K-12 settings (Scupelli, Wells-Papanek, Brooks, & Wasserman, 2017), other universities (Barbara & Scupelli, 2021), and on Massive Online Open Platforms in China (Scupelli, Fu, Zheng, & Brooks, 2019). In addition, I have described how design students understood CLA concerning design opportunities (Scupelli, 2020), embedding CLA into design practice (Scupelli, 2021) and differences between undergraduate design majors and non-design graduate students (Scupelli, 2022).

continuous access, integrative learning, and mimicking practice (Lawson & Dorst, 2009). One known challenge for design educators is to teach design methods within the school context so that students can transfer what they learned into professional practice.

Design students are often challenged to transfer design methods and applications learned in the classroom to other design courses and ultimately to their professional practice. Transfer of Learning is evident when learning in one context impacts performance in another (Perkins & Salomon, 1992).

Transfer can help or hinder learning. Transfer of Learning can be positive or negative. Positive Transfer enhances performance; Negative Transfer undermines performance (e.g., Perkins & Salomon, 1992). An example of Positive Transfer in design might be practicing design thinking methods on a simple problem and then applying the same design thinking methods to a more complex design problem. Likewise, a Negative Transfer example is applying a design thinking method learned for simple design problems to a complex problem where the simple method ignores critical information resulting in flawed solutions.

Transfer can occur across different kinds of tasks. First, one needs to understand the difference between simple and conflict problems. Siegler (1981) noted that two-dimensional tasks include two kinds of problems: simple problems and conflict problems. Simple problems allow information from the two task dimensions to be considered separately. For example, one might be comparing CLA analyses for two different populations in the same time period. Conflict problems require integration among the two relevant task dimensions. For example, examining CLA analyses for different populations (or specific contexts) across different time periods to develop a transition strategy roadmap to find design opportunities. Second, we need to describe strategies that support transfer. Task-specific instructions that provide scaffolding, with heuristics that more experienced learners might use, create large instructional gains (Butterfield & Ferretti, 1987; Siegler 1976). Two examples are the dimensional comparison strategy for simple problems and the dimensional integration strategy for solving conflict problems.

Transfer occurs across different contexts. Butterfield and Nelson (1991) identify four categories of transfer (within-task, across-tasks, discriminative, and inventive transfer). First, positive within-task transfer was defined as integration by adding dimensions on new problems from an instructed task (Butterfield & Nelson, 1991). For example, within task transfer might be learning to apply the CLA futures method to a design problem and then applying CLA to a new but similar problem.

Second, positive across-tasks transfer was defined as use of integration by adding on a task that has yet to be instructed (Butterfield & Nelson, 1991). A design example of across-tasks transfer might include, using CLA to analyse the status quo, and doing the CLA analysis for a future state, and then brainstorming the transition between status quo and future state without receiving instruction on how to do the brainstorming activity.

Third, positive discriminative transfer was defined as use of comparison on simple problems and use of integration by addition on conflict problems (Butterfield & Nelson, 1991). For example, a designer is asked to use CLA to analyse a specific future scenario for the year 2050 and analyze with CLA in the present time in a specific moment, place, and group. Discriminative transfer would require identifying strategic opportunities to transition to the 2050 scenario.

Fourth, positive inventive transfer was defined as use of integration by multiplication for untaught but required for correct solution of conflict problems unsolvable by addition (Butterfield & Nelson, 1991). A design example of inventive transfer might include conducting a CLA analysis for a design solution created in the present time frame and imagining how to design a similar product for a plausible 2050 Post-Anthropocene scenario where climate change issues are fully addressed (Schemel, Simunich, Luebkeman, Ozinsky, McCullough, & Bushnell, 2019)5. The designer would have to imagine a product solution that would work in the 2050 Post-Anthropocene scenario and imagine the transition roadmap for the product from the present status quo solution to the Post Anthropocene solution.

Transfer of knowledge can occur close or far to the initial learning (e.g., Perkins & Salomon, 1992). Near Transfer occurs between closely related learning contexts and performance application context. For example in a design education curriculum, a Near Transfer might be to apply a design method learned in a Design Futures class to a concurrent Design Studio class. Whereas Far Transfer is linked to different contexts and performances. For example, applying a futures-centered design method in professional practice.

Barnett and Ceci (2002) created a taxonomy with nine dimensions, including categories for types of knowledge and types of transfer situations. The taxonomy illustrates the broad range transfer of knowledge. Table 1 describes the dimensions of the content: what is transferred. The content, what is transferred, includes: learned skills, performance change, and memory demands.

Content: **What is Transferred**			
Learned skills	Procedure	Representation	Principle or Heuristic
Performance change	Speed	Accuracy	Approach
Memory demands	Execute only	Recognize and execute	Recall, recognize, and execute

Table 1. Content: what is transferred; learned skills, the performance change, and Memory demands. (Table adapted from Barnett and Ceci, 2002).

Table 2 describes the Context: when and where transferred from and to. The context, when and where transferred from and to includes: knowledge domain, physical context, temporal context, functional context, social context, and modality.

What level of cognition is involved with transfer? Reflexive or Low Road Transfer is linked to well-practiced routines being triggered (e.g., Perkins & Salomon, 1992). For example, one might practice Design Thinking methods repeatedly in school and then automate them in their professional practice. Instead, Mindful or High Road Transfer involves effortful abstraction and a search for connections. For example, one might abstract and theorize how a futures method can be adapted to a complex design problem.

Where does successful transfer occur? Successful transfer of learning requires a supportive context of practice. For example, transfer from training to real world applications is linked to alignment with contextual reward structures (Fleishman, 1987). The National Academies of Sciences book “Learning,

[5] These scenarios were developed by ARUP in 2019 and are available online: https://www.arup.com/perspectives/publications/research/section/2050-scenarios-four-plausible-futures

remembering, believing" provides extensive information on training for transfer from learning environments to application context (Druckman & Bjork, 1994). Transfer is easiest when the learning environment and performance environment are identical.[6]

Context: When and where transferred from and to	**Near ←**				**→ Far**
Knowledge domain	Mouse vs. Rat	Biology vs. botany	Biology vs. economy	Science vs. history	Science vs. art
Physical context	Same room at school	Different room at school	School vs. research lab	School vs. home	School vs. the beach
Temporal context	Same session	Next day	Weeks later	Months later	Years later
Functional context	Both academic	Both academic but one non-evaluative	Academic vs. filling in tax forms	Academic vs. informal questionnaire	Academic vs. at play
Social context	Both individual	Individual vs. pair	Individual vs. small group	Individual vs. large group	Individual vs. society
Modality	Both written same format	Both written, multiple choice vs. essay	Book learning vs. oral exam	Lecture vs. wine tasting	Lecture vs. wood carving

Table 2. Context, when and where transferred from and to. Context includes: knowledge domain, physical context, temporal context, functional context, social context, and modality. (Table adapted from Barnett and Ceci, 2002).

[6] Different levels of transfer are achieved based on what elements are and are not identical. Cognitive abstractions allow one to specify the elements of cognitive tasks (Anderson et al. , 1989; Bovair et al. 1990). Positive transfer is predicted by holding constant elements of cognitive tasks across learning and performance situations. According to Anderson's (1983) Adoptive Control of Thought (ACT) model, transfer is produced when cognitive abstractions formed in one context such as rules or knowledge chunks can be used in the performance. Gray and Orasanu (1987) provide an excellent review of skills transfer within the ACT model. The core idea is that there are two kinds of memory: declarative memory (e.g., facts that can be articulated as rules that with much practice can be performed automatically) and procedural memory (e.g., skill memory are condition-action or production rules). According to the ACT model, transfer between tasks occurs when there are shared elements in declarative or procedural memory.
Transfer may occur through analogy by extending knowledge from one situation to another (Anderson, 1993). Analogical transfer is rare unless a hint of the similarity of elements is provided (Holyoak, 1983). Logan (1988) posits that people performing tasks refer to past instances in memory. On the first task encounter people lack prior instances and thus use available strategies and rule based tools available. When tasks recur, performance is based on the first solution retrieved from memory. Ease or difficulty of transfer depends on more than the similarity of training and performance of task. For example, little transfer was shown between two structurally or formally similar identical problems that differed in superficial characteristics (Simon, 1980). An important aspect of cognitive skill transfer is to learn the skill but also recognize the situations when to apply the skill (Charney & Reder, 1987).
Transfer failure can occur when context or situation are very different. For example, a group trained to recognize flight paths, did flight path recognition well, but was unable to generate flight paths (Knerr et al. 1987). The Situated Learning approach (related to situate cognition and situated action) emphasises the social interactions in the task environment and situating the learner in the context of application (Lave, 1988; Lave & Wenger, 1991). They argued that (a) action is situated in the concrete situation where it occurs. (b) task organising elements are only present in situations not abstract representations of concepts. (c) Training by doing is more useful than training through abstractions. Apprenticeship facilitates learning through doing. (d) performance environments are social in nature and social interactions affect performance.

Next, I describe the Dexign Futures Context and Pedagogy to describe the training context of futures thinking methods.

1.5 Dexign Futures context and pedagogy

In 2014, at the School of Design at Carnegie Mellon University, Design Studies courses were added to equip 21st-century designers to address pervasive societal challenges, (Irwin, 2016). Currently, there are eight Design Studies courses each seven weeks long: Histories, Systems, Futures, Placing, Research Methods, Cultures, Power, and Persuasion. The Dexign Futures course was a required Design Studies course for third-year undergraduate design students from 2016 until fall 2022; starting in Spring 2022, it was required for all first-year undergraduate design students. For 2022 and 2023 the author taught both the first-year version in the spring semester and the third-year version in fall semester.

The Dexign Futures courses use a three-part design-centric flipped classroom pedagogy: pre-class online work with immediate feedback, in-class applied exercises, and written reflections (Scupelli & Brooks, 2018). The Dexign Futures courses taught to third-year and first-year students included the same content, learning objectives, and learning measures.[7]

1.6 How was CLA taught to the design students?

Overall, students learned CLA through five learning activities: (a) watching pre-class online videos, reading texts, and answering interactive questions with immediate correctness feedback, (b) in-class mini-lectures followed by class discussion, (c) in small group in-class on scaffolded step-by-step exercises, (d) writing individual online reflections and commenting on two classmates' reflections, and (e) followed by in-class small-group and whole-class discussions.

The flipped classroom pedagogy for design described above scaffolds students from abstract understandings of futures thinking to the application of such ideas into practical design applications. The reflection activities aimed to help learners generalize how they might apply newly learned futures thinking methods applied to design thinking problems more generally to their forming design practice.

There were two different CLA exercises: Personal Futures and Design Project Futures. The Personal Futures assignment was given in Fall 2021, Spring 2022, and Spring 2023. The Design Project Futures assignment was given in the Fall of 2022 and Spring of 2023. The first-year students in spring 2023 did both assignments.

The Personal Futures exercise comprised two in-class workshops that taught alternative futures and CLA. In the alternative personal futures workshop, students explored their past career decisions with a guided step-by-step exercise. First, they created a 2x2 matrix with two axes of uncertainty (Figure 1). For example, one axis could be defined by the two careers a student may have considered such as "medicine" and "design". The other axis might be defined by "research" and "professional practice". The four quadrants define four possible career paths: (a) professional designer, (b) clinical physician, (c) design researcher, and (d) medical researcher.

7 An external teaching consultant suggested minor changes to each course based on data-driven student focus groups conducted mid-way through each course. End-of-course faculty course evaluations provided insights for improvements for the next semester's course. Students requested minor changes like the logistics for turning in a project or shifts in how in-class discussions occurred.

Next, students explored four possible alternative careers. Students then picked one possible alternative career in the CLA workshop and explored it more in-depth through CLA-type analysis (i.e., litany, systems/infrastructure, worldviews, myths/metaphors). The four CLA layers allowed students to articulate what it might be like to work in that possible future career.

At the end of the week, students in the Personal Futures groups answered the reflection question:

> *You have explored alternative futures based on two critical uncertainties this week focused on career choice and related uncertainty (e.g., research/practice, corporate/freelance, government/NGO, and so forth). Then, you conducted a Causal Layered Analysis to describe the four layers (i.e., litany, social system & structure, worldview, and myths & metaphors) for one such future scenario. CLA is a structured analysis tool. What did you learn from conducting such an exercise? On what kind of projects might you use CLA-type analysis as a designer?*

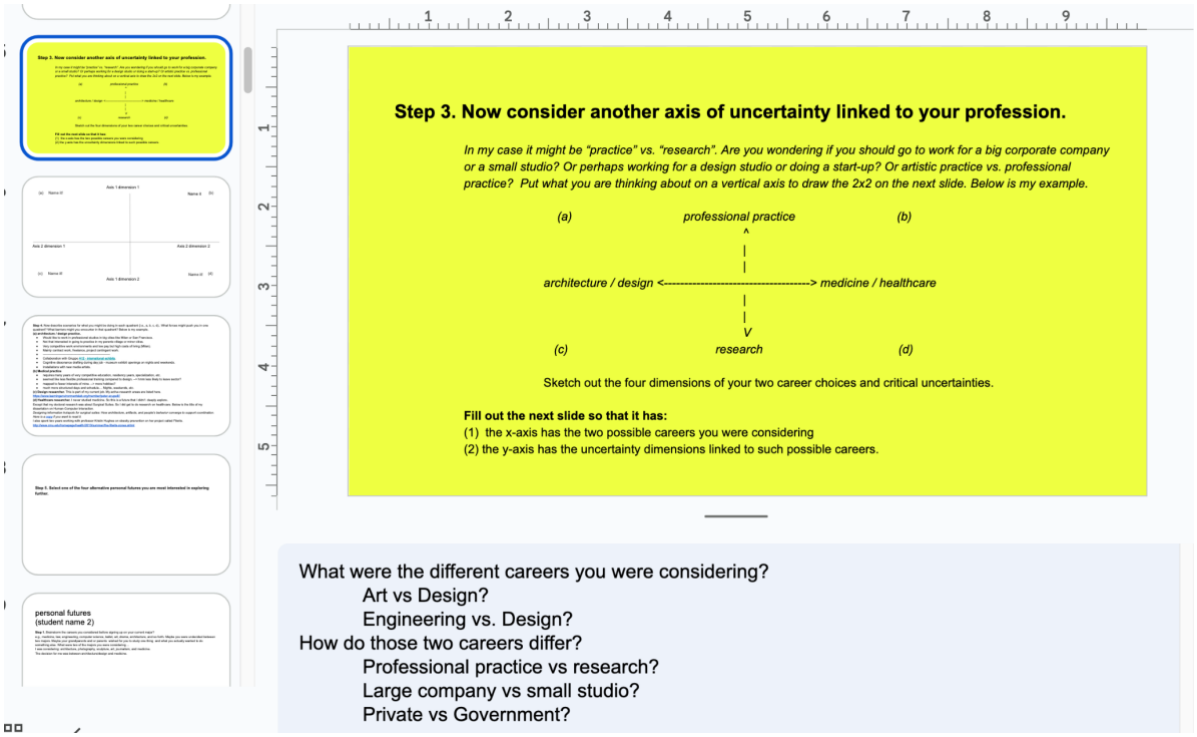
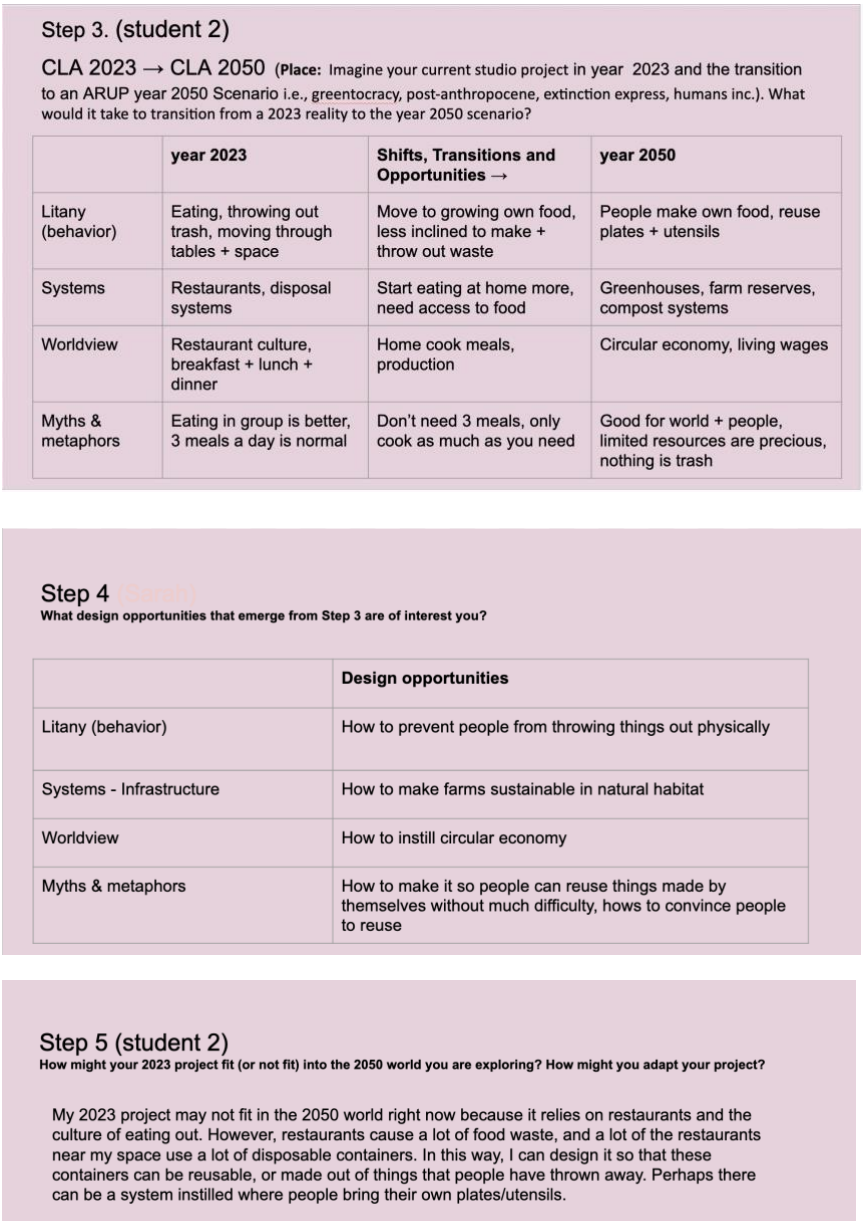


Figure 1. Instructions for the personal futures slide deck to consider the two career alternatives and two uncertainties about those career choices. There is an example based on architecture/design and medicine/healthcare on the x-axis and professional practice and research on the y-axis. (image ©LELAB)

The Design Project Futures had two in-class workshops focused on Alternative Futures and CLA. In the Alternative Futures exercise, students conducted a CLA analysis of the ARUP[8] Scenarios for 2050 (Schemel, Simunich, Luebkeman, Ozinsky, McCullough, & Bushnell, 2019). Each student team was assigned one of the four alternative futures: Post-Anthropocene, Greentocracy, Humans Inc., and Extinction Express. Students answered a series of scaffolded questions about the four layers of CLA (i.e., behavior, social infrastructure, worldview, myth/metaphor).

[8] ARUP is a British multinational professional services company headquartered in London that provides design, engineering, architecture, planning, and advisory services across every aspect of the built environment. https://en.wikipedia.org/wiki/Arup_Group

Next, students were asked to conduct a CLA analysis for a current studio project. Figure 2 shows the scaffolded questions students answered while applying CLA to one of their studio projects. In the second workshop, students mapped the gaps between the four layers of CLA for their design project in the present year and year 2050 ARUP Plausible Futures scenario. For each layer of CLA they identified transition gaps. Students focused on determining design opportunities that would emerge to transition the project in the present time to the particular ARUP future in year 2050.



Step 3. (student 2)

CLA 2023 → CLA 2050 **(Place:** Imagine your current studio project in year 2023 and the transition to an ARUP year 2050 Scenario i.e., greentocracy, post-anthropocene, extinction express, humans inc.). What would it take to transition from a 2023 reality to the year 2050 scenario?

	year 2023	**Shifts, Transitions and Opportunities →**	**year 2050**
Litany (behavior)	Eating, throwing out trash, moving through tables + space	Move to growing own food, less inclined to make + throw out waste	People make own food, reuse plates + utensils
Systems	Restaurants, disposal systems	Start eating at home more, need access to food	Greenhouses, farm reserves, compost systems
Worldview	Restaurant culture, breakfast + lunch + dinner	Home cook meals, production	Circular economy, living wages
Myths & metaphors	Eating in group is better, 3 meals a day is normal	Don't need 3 meals, only cook as much as you need	Good for world + people, limited resources are precious, nothing is trash

Step 4 (Sarah)

What design opportunities that emerge from Step 3 are of interest you?

	Design opportunities
Litany (behavior)	How to prevent people from throwing things out physically
Systems - Infrastructure	How to make farms sustainable in natural habitat
Worldview	How to instill circular economy
Myths & metaphors	How to make it so people can reuse things made by themselves without much difficulty, hows to convince people to reuse

Step 5 (student 2)

How might your 2023 project fit (or not fit) into the 2050 world you are exploring? How might you adapt your project?

My 2023 project may not fit in the 2050 world right now because it relies on restaurants and the culture of eating out. However, restaurants cause a lot of food waste, and a lot of the restaurants near my space use a lot of disposable containers. In this way, I can design it so that these containers can be reusable, or made out of things that people have thrown away. Perhaps there can be a system instilled where people bring their own plates/utensils.

Figure 2. Illustrates three of the scaffolded questions students answered for the Studio Project CLA exercise. Step 3 had students articulating the opportunities between the present and year 2050. Step 4 had students imagine design opportunities for each layer of CLA. Step 5 focused students on how to redesign their studio project so it might better fit into the specific year 2050 scenario (i.e., Post-Anthropocene, Greentocracy, Humans INC., Extinction Express). (image ©LELAB)

Students in the Studio Project condition answered the reflection question below.

Alternative Futures, CLA, and your studio project. You've explored alternative futures based on ARUP futures for 2050 (i.e., Post-Anthropocene, Extinction Express, Greentocracy, Humans Inc). In the class assignment, you conducted a Causal Layered Analysis for one ARUP 2050 scenario to describe the four layers (i.e., litany, social system & structure, worldview, and myths & metaphors). You also did a CLA analysis of your studio project in [2022, 2023] and mapped the gap between [2022, 2023] and the 2050 scenario. to imagine the transition space of opportunity. CLA is a structured analysis tool. What did you learn from conducting such an exercise? On what kind of projects might you use CLA-type analysis?

In the next section, I discuss the research questions comparing two different ways of learning to apply CLA to design for first and third year design undergraduate students.

2 Research questions

In this paper, I compare undergraduate design students in first-year and third-year learning to use CLA with two different exercises, personal futures and studio project exercises. The course materials and course instructor were the same for all courses. Research questions: (1) Does the type of exercise to learn CLA influence how students imagine how CLA might be used in their future design methods and design practice? (2) Does the year of study impact how students imagine how CLA might be used in their future design methods and design practice?

3 Data

Due to a change in the curriculum, the Dexign Futures class was moved from a required class for third-year undergraduate design students to a required class for first-year undergraduate design students. I taught the same Dexign Futures course to first and third-year student cohorts. During the transitional two-year period to the new curriculum, each semester, the Dexign Futures course was offered twice: in the spring semester as a required course for first-year undergraduate design majors, and in the fall semester as required course for third-year undergraduate design students.

In this paper, I analyze data from four such courses. Two sections were first-year students and two sections were third-year students (Table 3). Fall 2021 third-year students in did the personal futures CLA exercise. Fall 2022 third-year students did the design studio CLA exercise. Spring 2022 first-year students did the personal futures CLA exercise. Spring 2023 first-year students did both the personal futures and the design studio CLA exercise.

*Table 3. Number of participants by year of undergraduate design students (first-year vs third-year) and type of CLA exercise assigned (personal futures or Studio Project). *Please note that the First year Spring 2023 students did both the Personal Futures and Studio Project exercises.*

	Year students	**Reflection**	**N**
2021 - fall	Third	Personal futures	34
2022 - spring	First	Personal futures	39
2022 - fall	Third	Studio project	30
2023 - spring*	First	Personal futures	39
2023 - spring*	First	Studio project	41

The number of students differed by course year-first years (N= 80) and third-year design students (N= 64). Overall, of the 212 weekly reflections submitted from students, approximately 69% were submitted from female students. The data and the coding scheme were described previously (Scupelli, 2021; 2022). In this paper, I focus on the differences in learning CLA with two different assignments: the Personal Futures and Studio Project. Next, I provide a summary of the methods.

4 Methods

The coding scheme in this study was previously developed with grounded theory methods in three steps: (a) initial coding, (b) intermediate coding, and (c) advanced coding (Strauss & Corbin, 1998). The five codes used were: personal insights, design insights, thinking structures, CLA details, and others (Table 4). The *personal insights* code describes students' reflections focused on how CLA explained their career or personal choices. The *design insights* code described how CLA could inform design methods and processes. The *thinking structures* code refers to how the different CLA layers can help structure one's Thinking. The *CLA details* code describes CLA layers and linkages between CLA to other futures methods. Finally, I assigned the *other* code when the previous four codes were inappropriate.

	Definition
Personal Insights	Focused on personal insights from CLA or futures methods.
Design Insights	Reflections on how CLA might be used in design methods or processes.
Thinking Structures	The text describes how different layers of CLA structure thinking or provide contextual insights (e.g., relationships between CLA layers, question assumptions about the status quo, cultural context). Thinking through multiple perspectives (e.g., individuals, groups, organisations).
CLA details	The text explores details of the CLA layers (i.e., litany, systems, worldview, myth/metaphor) and/or mentions links from CLA to other futures thinking methods.
Other	The text does not fit into the previously described codes.

Table 4. The five codes used to code the student reflections on CLA (Source: Scupelli, 2022)

5 Statistical analyses

In this section, I describe the statistical analysis for the three studies. Study one compares all the data together by condition Personal Futures vs. Studio Project with an ANOVA statistical test. Study two compared the Spring 2023 first-year students who did both the Personal Futures and the Studio Project exercises. Since each first year in participant did both exercises, a Repeated Measures T-test was used to compare the two treatments. Study three compared third-year students from 2021 and 2022. An ANOVA test was used since the experimental groups were independent.

6 Results

In this section, I describe the results in five sections: (a) I describe the data overall. (b) in Study 1, I compare the number of codes by type of assignment (Personal Futures vs. Studio Project). (c) In Study 2, I compare the differences between Personal Futures and Studio Project for first-year students. (d)

In Study 3, I compare the differences between Personal Futures and Studio Project for third-year students. (e) I explore texts written by first and third-year undergraduate design students.

6.1 Data overview

Overall, 183 student reflections were coded (Table 5). Approximately 69% of participants in all classes were female. The range for females in each cohort went from Min = 65% female to Max = 77% female. On average students wrote 126.60 words (Max 300 words, Min 44 words, median 122 words) with a standard deviation of 42.57 words. In the next section, I describe the distribution of codes according to the type of assignment (i.e., Studio Project vs. Personal Futures).

6.2 Study 1. Assignment type: Studio Project vs. Personal Futures

The type of assignment was associated with significantly different types of student reflection responses (Figure 3). Most interestingly, Courses with the Studio Project assignment were associated with significantly more "Design Insights" compared to students reflecting on their Personal Futures assignments. Inversely, significantly more "Personal Insights" were coded for students' reflections in the "Personal Futures" assignment courses.

Table 5. Illustrates the number of codes overall by type of learning exercise (Studio Project vs Personal Futures).

	Personal Insight	Design Insight	Thinking Structure	CLA Details	Other	Total
Studio Project	7	44	14	2	4	71
Personal Futures	39	34	29	4	6	112

I did an ANOVA analysis by personal futures and studio project conditions to compare the coding of students' reflections (i.e., personal insights, design insights, CLA Structure for thinking, CLA details, and other). There was a significant difference by course for *Personal Insights* [$F(1, 181) = 12.27$, $p < .001$] and Design Insights [$F(1, 181) = 15.65$, $p < .001$] (Figure 03).

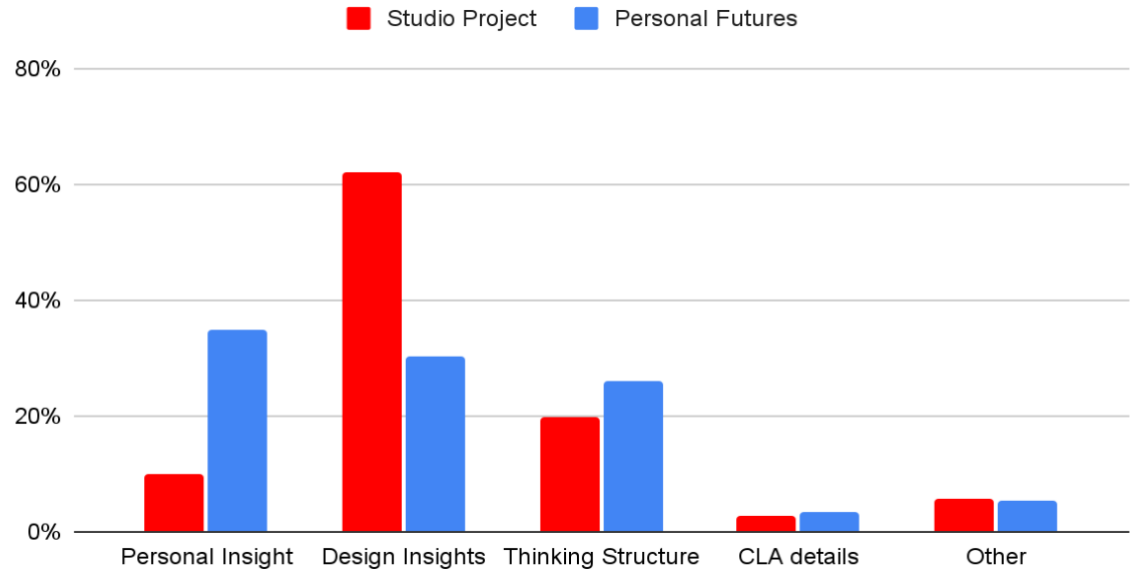


Figure 3. Bar graphs for student reflections coded as personal insights, design insights, thinking structures, CLA details, and other for Studio Project vs Personal Futures groups (image ©LELAB).

6.3 Study 2 - Studio Project vs. Personal Futures for first-year design students

Figure 4 is a bar graph that shows the distribution of codes (i.e., personal insights, design insights, CLA Structure for thinking, CLA details, and other) according to the type of assignment (personal futures vs. studio project) for first-year design students.

Thirty five first year students did both the personal futures and the studio project reflections. A paired samples test was conducted on the Spring 2023 first-year students since they did both experimental conditions. The Personal Futures assignment in week 5 followed by the Studio Project assignment in week 6. The Paired Samples Test confirmed there were significantly more Personal Insights in the Personal Futures condition compared to the Studio Project condition, $t(35) = 2.02$, $p = .05$ and significantly more Design Insights in the Studio Project condition, $t(35) = -2.25$, $p < .03$ (figure 4).

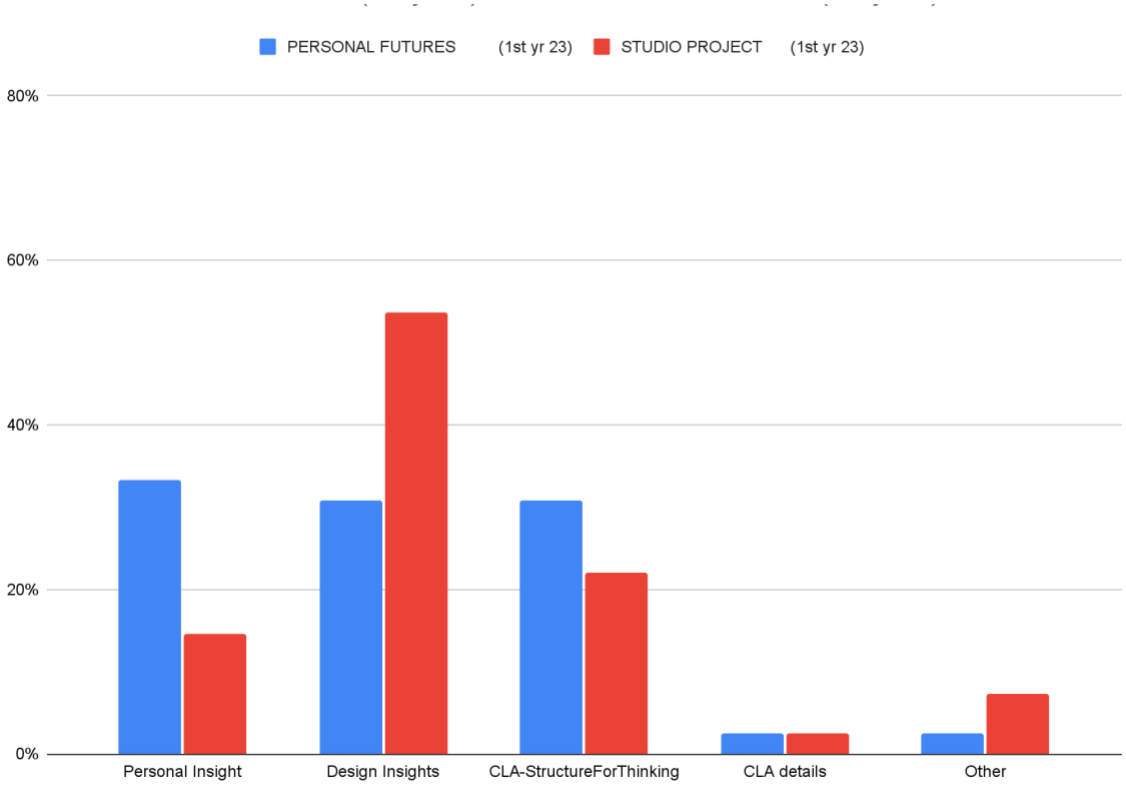


Figure 4. Bar graph for student reflections coded as personal insights, design insights, thinking structures, CLA details, and other for Studio Project vs Personal Futures by student year (first year vs third year). First-year bar graph comparing Personal Futures and Project Studio (image ©LELAB).

6.4 Study 3 - Studio Project vs. Personal Futures for third-year design students

Figure 5 is a bar graph that shows the distribution of codes (i.e., personal insights, design insights, CLA Structure for thinking, CLA details, and other) according to the type of assignment (personal futures vs. studio project) for third-year design students.

Sixty-four third-year students total submitted reflections (N=34 in the Personal Futures and N=30 in the Studio Project condition). An ANOVA analysis was conducted to compare the coding of students' reflections (i.e., personal insights, design insights, CLA Structure for thinking, CLA details, and other).

There was a significant difference by course. More personal insights for the third year courses in the Personal Futures condition [$F(1, 63) = 15.38$, $p < .001$] and more design insights for the third year courses in the Studio Project condition [$F(1, 63) = 12.47$, $p < .001$] (figure 5).

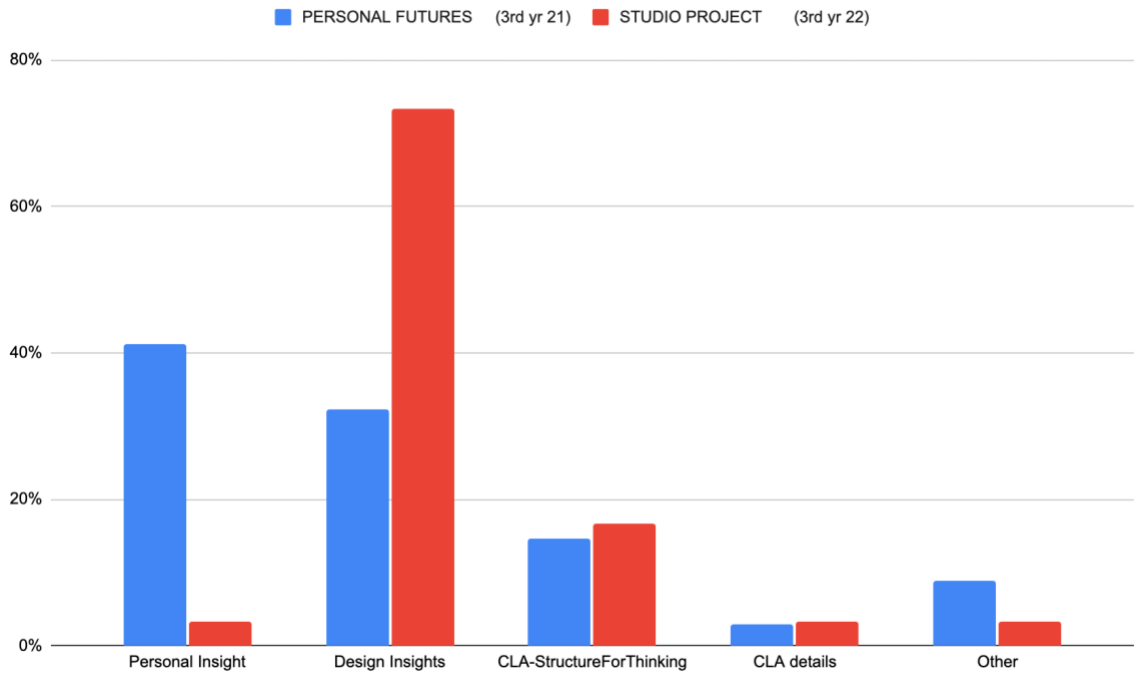


Figure 5. Bar graphs for student reflections coded as personal insights, design insights, thinking structures, CLA details, and other for Studio Project vs Personal Futures by student year (first year vs third year). Third-year bar graph comparing Personal Furtures and Project Studio, (image ©LELAB).

6.5 Comparing personal insights and design insights texts

Here are two examples of personal insights from a first-year and a third-year undergraduate design students in the Personal Futures cohorts. CLA and the Personal Futures assignment provide students with insights on their career trajectories. The first-year student's personal reflections focus on future career options and how different layers of CLA analysis impact one's experience.9 Likewise, the third-year student explores how the alternative personal futures exercise and CLA analysis afforded to reimagine one's career trajectory and personal strengths.[10]

[9] Participant 187, a first-year in the Spring 2022 cohort that did the Personal Futures assignment.
"This exercise allowed me to consider the different factors that would impact my future career. Prior to reading about the four layers, I had always considered my future job to be something that was determined mainly by my own work effort and experiences. I knew about the systemic and structures surrounding my future, but I was able to gain more insight into the specific relationships in professional settings that would affect me (employers, networking for projects, etc). After conducting the analysis on the different layers, I realized just how much the worldview and myths aspect affected me as well."

[10] Participant 141, a third-year in the Fall 2021 cohort that did the Personal Futures assignment.
"From using this Personal Futures & CLA exercise, I was able to figure out how my future can be diverse and specific depending on how I take my steps every time. It was a new realisation for me to think about alternative future, other than a motion designer. We usually don't think about our past and imagine how it would've been. For me, I had "Large / Small-scale Practice" and "Motion & Design / Digital / Tech-Service & Computer science" aspects for my choices and those made me to think that the creativity is what I have the most and confidence the most. This exercises allowed me to have wider world views with broader aspects on a large society that I've living right now. I might use CLA type analysis as a designer when I need compare and contrast topic practices."

Next, are two examples of design insights from first-year and a third-year undergraduate design students in the Studio Project cohorts. Unsurprisingly, both first and third-year students notice the details of their studio projects. The design insights are linked to broadening the design space to consider. The first-year student ponders how worldviews and myth/metaphors affect designed products.[11] The third-year student is noticing how layers like worldview and myths/metaphors for the year 2050 shift the concept away from wasteful marketing towards "repurposing materials. prototyping digitally" and "emphasizing DIY culture" in the revised project.[12]

Next, I provide two examples of design insights from the personal futures cohorts to illustrate how the reflections shift. The focus is more on real-world design applications and less linked to their own projects. A first-year student posits that CLA analysis is "a fantastic framework for design research" noting that companies like AirB&B changed "perception of strangers" shifting myths and "opened doors that were once closed."[13] A third-year student in the Personal Futures assignment cohort notices how CLA opens access to deeper layers around a design problem/opportunity to consider strategic links between design decisions and worldview and myth/metaphor layers.[14].

[11] Participant 292, a first-year in the Studio Project cohort in Spring 2023.
"The CLA exercises and maps were really helpful ways and methods to contextualise both projects we've been working on in studio classes as well as the general understanding of the purpose and potential of design as a whole. I think the breaking down into the four causal layers helps one understand more complex systems and concepts that may be overwhelming otherwise, I found it interesting that there was a layer dedicated specifically towards "myths and metaphors" as I hadn't considered how assumptions or stereotypes affect our views of products, structures or systems as compared to "worldview", and by separating the two, gave me a better understanding of them, and a means to apply it to future projects. In terms of what kinds of projects, I can how it could be used to unpack systemic or socially integrated issues in a more objective manner, and a means to provide a better alternative."

[12] Participant 197, a third-year in the Studio Project cohort in Fall 2022.
"I thought the future scenario of greenotocracy was interesting, thinking about a worldview that is not as conventional where DIY culture and repurposing materials is valued. Some elements of it seemed promising for the future such as 100% green energy use and international climate regulations. Thinking about our own projects in 2022 allowed me to actually apply the CLA model to my life which made me realize how capitalistic and individualistic a lot of current activities are. Since I'm working on developing a branding experience, I was able to consider CLA with my company's brand values. For every company, there's a heavy emphasis on wasteful advertising to increase consumers to generate revenue. The 2050 future transformation allowed me to think of what I should prioritize when designing my experience such as sustainable experiences, instead of building physical prototypes using materials- building models digitally and repurposing materials, finding new ways to represent brands instead of just marketing, emphasize DIY culture, and consider long term effects of my design experience and how it will influence society."

[13] Participant 154, first-year student in the Personal Futures 2023 spring cohort's reflection coded as design insights.
"Using CLA analysis seems like a fantastic framework for design research, which I'm starting to think (or realize) is at the heart of design. Designing ethically requires that you attempt to understand how a problem trickles through all four layers of society. We recognize that our action's consequences can never be wholly predicted, especially when they reach the worldview and myth layers. AirB&B has changed our perception of strangers, neighbourhoods, and the role of a landlord. I don't know how deeply that company considered their myth bending, but it certainly opened doors that were once closed. Our conversation in the last class gave me some hope as to how a company can do good by just self reflecting."

[14] Participant 120, third-year student in the Personal Futures 2021 fall cohort's reflection coded as design insights.
"Applying the CLA to my future scenario allowed me to think both superficially and deeply about what the future would look like while buildin it. I also think that the deeper layers allowed me to assess the 'metadata' or second-order thinking of how I was going about thinking about my future in these ways. I think that I would use CLA analysis as a method for justifying or positioning design decisions relative to the user and design space in more nuanced social projects. By situating high-level

7 Discussion

The discussion section is organized into four sections: (a) does the type of training matter? (b) does the year of study matter? (c) are two exercises better than one? and, (d) Transfer of knowledge.

7.1 Does the type of training matter?

Yes, the type of training matters for knowledge transfer. The type of assignment students did to learn CLA was significantly associated with the type of reflections they wrote. The Personal Futures assignment was first introduced because it allowed students to apply CLA to something of interest to the students. In previous research (Scupelli, 2021; 2022), it was clear that most design students understood CLA well but over 53% of students struggled to transfer CLA to design methods and processes. In fact, in the 2022 study, only 19.8% of design students described design insights. That low percentage motivated this research study to test a new way to teach CLA to design students so that they can transfer CLA to design methods and design practice. This study confirms the previous findings, in that the students that did the Personal Futures assignment to learn CLA, significantly wrote more reflections coded as Personal Insights.

The Studio Project Condition was chosen because it forced students to apply CLA to a design project they were working on. Overall, the students in the Studio Project condition on average more than tripled the number of Design Insights compared to the previous study (2023 - 62% vs 2022 - 19.8%). The main effect was visible for both first-year undergraduate (Design Insights 54%) and third-year undergraduate design students (Design Insights 73%). The main effect of assignment type was also visible for the first-year students in Spring 2023 that did the Personal Futures assignment one week followed (Design Insights 31%) by the Studio Futures assignment the next week (Design Insights 54%). The main finding of this study is that the Studio Project assignment was associated with a greater capacity to transfer Futures Thinking methods such as CLA to design practice as measured in students' written reflections.

7.2 Does the year of study matter?

Within the Studio Project condition and the Personal Futures condition, I found no statistically significant differences between first-year and third-year undergraduate design students. In other words, first-year and third-year students statistically had the same quantity of reflections within each condition. I interpret this to mean that the age of the student and the year of training had no significant impact on the capacity to articulate reflections coded as Design Insights in the Studio Project and the same was true for the Personal Insights in the Personal Futures assignment group. Further research is needed to assess if there are qualitative differences in the type and quality of design insights produced by first-year and third-year design students. Intuitively one would expect to find qualitative differences in how first-year and third-year students describe design methods. Prior research described significant differences between undergraduate design students when compared to non-design graduate students (Scupelli, 2022). From the previous research, it is unclear if the differences observed were due to the age differences between undergraduate design students and graduate students or the differences in majors (design major vs. non-design major).

concepts or strategies in the design using the higher level spaces like Worldview and Myths, the analysis then allows me to see the 'trickle down' effects of those decisions and how they manifest at the surface level layers such as Litany."

7.3 Are two CLA exercises better than one?

It is unclear if the first-year students in Spring-2023 (who did both the Personal Futures and Studio Project assignments) were helped to perform at a similar level as the third-year students in Fall-2022 who did only the Studio Project assignment. Given the significant differences between the two assignments (and the transfer of knowledge mechanisms described in the next section), it seems unlikely that the Personal Futures assignment improved the first-year student's performance on the Studio Project assignment. Since all students did the Personal Futures and Studio Project assignments in the same order it is unclear if there is an order effect. Further empirical research is needed to know for sure. The first-year students and the third-year students in the Studio Project condition had statistically similar amounts of personal insights and design insights.

7.4 Transfer of knowledge mechanisms

The goal of this study was to explore how two different activities to learn CLA impacted how students imagined transferring the CLA futures method to their design practice. The higher transfer of knowledge in the Studio Project exercise is likely explained by more mechanisms of knowledge transfer embedded into the exercises compared to the Personal Futures exercise. Butterfield and Nelson (1991) posit four categories of transfer within-task, across-tasks, discriminative, and inventive transfer. Next, I describe three learning transfer areas for both exercises. First, students learned about the CLA futures method through an interactive online learning activity followed by in-class small group discussion and large class discussion. This is a within-task transfer because CLA was integrated into similar new problems.

Second, during-class, students in small teams transferred CLA inspired futures thinking into design type activities through scaffolded exercises. The Personal Futures exercise had students do within-task transfer, applying CLA to a personal future. Instead, the Studio Project exercise included across-task transfer (applying CLA to a 2050 scenario followed by the CLA of design project) and discriminative transfer (identifying strategic design opportunities to transition from the present time to a 2050 scenario). And third, in their weekly reflection, students imagined how they might transfer CLA into their future related design practices. Inventive transfer describes the type of transfer. The evidence in this study can be interpreted to mean that inventive transfer is more difficult when fewer categories of transfer are applied previously (in the Personal Futures compared to the Studio Project condition).

8 Summary

We live in challenging times; the unfolding Climate disaster, threats of nuclear war, and urgent decarbonization to reach zero-carbon lifestyles by year 2050. Design educators are challenged to teach new design methods and processes that allow short-term design action to align with long-term strategic sustainable vision goals. In this paper, I described Dexign Futures an emergent form of design methods and tools that merge futures thinking and design thinking. In previous research, I noted that a Personal Futures assignment to teach CLA was associated with only 19.8% of design students articulating how they might use CLA in their design practices. In this study, I compared first-year and third-year design students using a Personal Futures assignment to a Studio Project assignment. Over three time as many design students, 62% of students who did the Studio Project assignment described how to apply CLA within design methods or design processes. I posit that one of the key differences between the Personal Futures assignment to a Studio Project assignments are the underlying transfer

of knowledge categories embedded within each exercise. Namely, the Studio Project assignment required four kinds of transfer within-task, across-tasks, discriminative, and inventive transfer (Butterfield & Nelson, 1991). The Personal Futures assignment instead required only within-task making the inventive transfer task more challenging for most students. I found no significant differences in the number of Design Insights that first-year and third-year design students generated. I propose future work to explore if there are any qualitative differences between the first-year and third-year design student insights. Prior research, (Scupelli, 2022) described significant differences between undergraduate design students when compared to graduate students that were non-design students; it is unclear if the reported differences were due to the age differences (undergraduate vs graduate) or the differences in major of study (design vs. non-design majors).

References

Abdullah, A. (2022). Futures studies for high schools in Taiwan: An introduction. https://jfsdigital.org/2022/05/30/futures-studies-for-high-school-in-taiwan/

Anderson, J.R., Conrad, F.G. & Corbett, A.T. (1989) Skill acquisition and the LISP tutor. *Cognitive Science* 13:467-506.

Anderson, J.R. (1976) Language, Memory, and Thought . Hillsdale, N.J.: Lawrence Erlbaum. 1983 *The Architecture of Cognition*. Harvard University Press. 1993 *Rules of the Mind*. Lawrence Erlbaum.

Barnett, S., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin*, 128, 612–637.

Barbara, A., & Scupelli, P. (2021). Teaching to Dexign futures in cities. *TECHNE*

Bishop, P. & Kay E. Strong. (2010). Why teach the future? *Journal of Futures Studies*, 14(4), 99–106.

Bovair, S., Kieras,D.E. & Polson, P.G. (1990) The acquisition and performance of text-editing skill: A cognitive complexity analysis. *Human-Computer Interaction* 5:1-48 .

Butterfield, E. C., & Ferretti, R. P. (1987). Toward a theoretical integration of hypotheses about intellectual differences among children. In J. G. Borkowski & J. D. Day (Eds.), *Cognition in special children* (pp. 195-233).

Butterfield, E. C., & Nelson, G. D. (1991). Promoting positive transfer of different types. *Cognition and Instruction,* 8(1), 69–102.

Candy, S. (2010). *The futures of everyday life: Politics and the design of experiential scenarios*. University of Hawaii.

Ceschin F. & Gaziulusoy İdil. (2020). *Design for sustainability : a multi-level framework from products to socio-technical systems*. Routledge.

Charney, D.H., & L.M. Reder (1987) Initial skill learning: An analysis of how elaborations facilitate the three components. In P. Morris, ed., *Modeling Cognition* . John Wiley & Sons.

Doerr, J. & Panchadsaram, R. (2021). *Speed and scale: An action plan for solving our climate crisis now.* Penguin Business.

Druckman D. Bjork R. A. & National Research Council (U.S.). (1994). *Learning, remembering, believing: enhancing human performance.* National Academy Press.

Dunne, A. (1999). *Hertzian tales: Electronic products, aesthetic experience, and critical design*. Royal College of Art computer-related design research studio.

Dunne, A., & Raby, F. (2013). *Speculative everything: Design, fiction, and social dreaming.*

Farrell, C., Green, A., Knights, S., & Skeaping, W. (2019). *This is not a drill: An extinction rebellion handbook.* Penguin.

Fleishman, E. (1987) Foreword in Cormier, S. M., & Hagman, J. D. (Eds.). (2014). *Transfer of learning: Contemporary research and applications*. Academic press.

Gates, B. (2021). *How to avoid a climate disaster: The solutions we have and the breakthroughs we need*. Allen Lane.

Glenn, J. (1972). Futurizing teaching vs. futures courses. *Social Science Record*, 9(3), 26–29.

Godin S. (2022). *The carbon almanac: it's not too late.* Portfolio Penguin.

Gray, W.D., & Orasanu, J.M. (1987) Transfer of cognitive skills. In S.M. Cormier and J.D. Hagman, eds., *Transfer of Learning: Contemporary Research and Applications*. Academic Press.
Griffith, S. (2021). Electrify: An optimist's playbook for our clean energy future. MIT Press.
Häggström, M. & Schmidt, C. (2021). Futures literacy – To belong, participate and act!: An Educational perspective. Futures, 132. https://doi.org/10.1016/j.futures.2021.102813
Hawken, P. (2021). *Regeneration: Ending the climate crisis in one generation.* Penguin Books.
Holyoak, K.J. (1984) Analogical thinking and human intelligence. Pp. 199-230 in R.J. Sternberg, ed., *Advances in the Psychology of Human Intelligence*, Vol. 2. Lawrence Erlbaum
Inayatullah, S. (1998). Causal layered analysis: Poststructuralism as method. *Futures*, 30(8), 815-829.
Inayatullah, S. (2004). *The causal layered analysis (CLA) reader: Theory and case studies of an integrative and transformative methodology*. Tamkang University Press.
Inayatullah, S. (2009). Causal layered analysis: An integrative and transformative theory and method. *Futures Research Methodology*, Version, 3.
Inayatullah, S., & Milojevic, I. (2015). *CLA 2.0: Transformative research in theory and practice*. Tamkang University Press.
Inayatullah, S., Mercer, R., Milojevic', I., & Sweney, J. (2022) *CLA 3.0: Thirty Years of Transformative Research.* Tamkang University Press.
IPCCC (2022) https://www.ipcc.ch/reports/
Irwin, T. (2016, February 21). Redesigning a design program: How Carnegie Mellon University is developing a design curricula for the 21st century. *The Solutions Journal*. https://thesolutionsjournal.com/2016/02/22/redesigning-a-design-program-how-carnegie-mellon-university-is-developing-a-design-curricula-for-the-21st-century/
Knerr, C.M., Morrison, J.E., Mumaw, R.J., Stein, D.J., Sticha, P.J. Hoffman,R.G., Buede, D.M., & Holding, D.M. (1987) *Simulation-Based Research in Part-Task Training*. AF HRL-TR-86-12, AD-B107 293. Air Force Human Resources Laboratory, Brooks Air Force Base, Tex.
Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. Cambridge University Press.
Lave, J., & Wenger, E. (1991) *Situated Learning: Legitimate Peripheral Participation.* Cambridge University Press
Lawson, B., & Dorst, K. (2009). *Design expertise.* Architectural Press.
Logan, G.D. (1988) Toward an instance theory of automatization. *Psychological Review* 95:492-527.
Mitrović, I., Auger, J., Hanna, J., & Helgason, I. (2021) Beyond Speculative Design: Past – Present – Future, SpeculativeEdu; Arts Academy, University of Split.
Morrison, A., Celi, M. & Cleriès, L. (2021). 'Anticipatory design and futures literacies.' In *Proceedings of CUMULUS ROME 2020.* https://cumulusroma2020.org/
Mulvey, K. & Shulman, S. (2015). *The climate deception dossiers: Internal fossil fuel industry memos reveal decades of corporate disinformation*. Union of Concerned Scientists. https://www.ucsusa.org/sites/default/files/attach/2015/07/The-Climate-Deception-Dossiers.pdf
Perkins, D. N., & Salomon, G. (1992). Transfer of learning. *International Encyclopedia of Education* (2nd ed.). Pergamon Press.
Raby, F. (2001). *Design noir: The secret life of electronic objects.*
Schemel, S., Simunich, J., Luebkeman, C., Ozinsky, A., McCullough, R., & Bushnell, L. (2019). Four Plausible Futures 2050 Scenarios (p. 68). ARUP. https://www.arup.com/perspectives/publications/research/section/2050-scenarios-four-plausible-futures
Scupelli, P. (2022). Does When and How Design Students Learn Causal Layered Analysis Matter? Journal of Futures Studies. Vol. 27, No. 2, pp 28-41
Scupelli, P. (2021). Teaching designers to anticipate future challenges with causal layered analysis. IASDR 2021: With Design: Reinventing Design Modes. December 5-9, 2021. https://www.sd.polyu.edu.hk/iasdr2021/abstracts/download.php
Scupelli, P. (2020). Teaching to find design opportunities for behavior change through causal layered analysis. In: Rau, PL. (Eds) Cross-Cultural Design. User Experience of Products, Services, and Intelligent Environments. HCII 2020. Lecture Notes in Computer Science: Vol. 12192. Springer. https://doi.org/10.1007/978-3-030-49788-0_10

Scupelli, P., Candy, S., & Brooks, (2019). Teaching futures: Trade-offs between flipped classroom and design studio course pedagogies. Proceedings of IASDR 2019: Design Revolutions. September 2-5, 2019. https://iasdr2019.org/uploads/files/Proceedings/le-f-1310-Scu-P.pdf

Scupelli, P., Fu, Z., Zheng, Y. & Brooks, J. (2019). Teaching to Dexign futures in China: A vision for a blended learning pedagogy to be deployed at scale. 9th International Conference on the Future of Education. https://conference.pixel-online.net/FOE/files/foe/ed0009/FP/5769-ITLM3915-FP-FOE9.pdf

Scupelli, P., & Brooks, J. (2018). What features of a flipped course improve design student learning experiences? Academic Design Management Conference ADMC18, (August 1-2, 2018) https://dexignfutures.files.wordpress.com/2016/08/scupelli_wasserman_wellspapanek_brooks2018finalred.pdf

Scupelli, P., Wells-Papanek, D., Brooks, J. & Wasserman, A. (2017). Opening a design education pipeline from University to K-12 and Back. Proceedings of IASDR 2017, (October 31 – November 3, 2017). https://scholar.uc.edu/downloads/f1881k909?locale=zh

Scupelli, P., Wasserman, A., Brooks, J. (2016). Dexign futures: A pedagogy for long-horizon design scenarios. Proceedings of DRS 2016, Design Research Society 50th Anniversary Conference. 27–30 June 2016. https://www.drs2016.org/348

Siegler, R. S. (1981). Developmental sequences within and between concepts. *Monographs of the Society for Research in Child Development*, 46(2, Serial No 189).

Siegler, R. S. (1976). Three aspects of cognitive development. *Cognitive Psychology*, 8, 481-520.

Simon, H.A. (1980) Problem solving and education. Pp. 81-92 in D.T. Tuma and F. Reif, eds., *Problem Solving and Education.* Lawrence Erlbaum

Slaughter, R. (2008). Futures education: Catalyst for our times. *Journal of Futures Studies*, *12*(3), 15–30.

Sterling, B. (2005). *Shaping things*. MIT Press.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Sage Publications.

Strong, K. E., & Bishop, P. C. (2011). Case study: Futurizing the K-12 teaching practice. *Journal of Futures Studies*, 15(4), 181–188.

TED (2019) https://countdown.ted.com/

Tharp, B. M., & Tharp, S. M. (2019). *Discursive design: Critical, speculative, and alternative things*. MIT press.

Toffler, A. (1970). *Future shock*. Random House.

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