CIRCULAR STUDIO - COMBINING HERITAGE, TRANSFORMATION, RE-USE AND EMISSIONS TO A HOLISTIC STUDENT-ACTIVE LEARNING EXPERIENCE IN ARCHITECTURE

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ABSTRACT

Background and aim. Norway has approximately 6000 professional architects in its workforce. Their historical and current bulk of new-built projects will become scarcer as climate change, nature loss and societal considerations force increased use of existing buildings. It is therefore necessary that new architects have a solid, updated, and coherent education in efficiently working with existing buildings as they enter the workforce. This study follows the introduction of Circular Studio, a piloting curriculum development architectural studio course that focuses on existing buildings, re-use of materials and design development, aiming to report the identified concepts and perspectives as manifestations of experiential learning.

Methods and Data. The study utilised a before-after survey (N=19 first iteration, N=19 second iteration, of which 10 were matched pairs). Measured dimensions were correlation to NEP-15 environmental attitudes, BIDR Impression management, 20 statements about buildings focusing on resource use and circularity, 16 statements on the role of architects and 2 open questions focusing in the positive and negative impacts of architects as agents, as well as opportunities and barriers.

Findings. The explorative approach identified 5 concepts and perspectives as well as a multitude of indications on individual aspects of experiential learning in Circular Studio.

Practical implications. The study provides an initial test for a framework for the practical design of circularity curriculum in architectural education and suggestions for co-developing curriculum and evaluation research for evidence-based development for this shift in the architectural profession.

KEYWORDS: architectural education, Circular Economy, experiential learning, perception change

1 BACKGROUND AND AIM

Architectural education of the last decades differs from many higher educations by the central role of the design studio, understood as both a physical space, as well as a pedagogical approach to learning by doing (Corazzo, 2019; Schon, 1987). As a material space, the studio houses making objects, bridging contexts, building meaning, enabling activities as well as a background for learning and a space the enables the expression of disciplinary identity (Corazzo, 2019).The latter, forming an identity as a practitioner and the development of joint norms within the profession, is enabled through the studio as a space of immersion and expected behaviour (Boling et al., 2016; Corazzo, 2019; Thoring et al., 2018) and becoming insiders by iterative processes of solving problems, expressing solutions and shaping their own identities (Corazzo, 2019). In architectural education, the studio (as both physical space and pedagogical concept) is an integral part of the interplay between active learning, informal and creative learning spaces, participating in a collective with both fellow students and staff and forming ones identity (Aalto et al., 2023; Corazzo, 2019; Leijon et al., 2022; Lundahl et al., 2017; Thoring et al., 2018, 2019). Supported by smaller courses on theory, methods or knowledge building, *the studio* has also become synonymous with a teaching unit or a course in order to achieve an immersive, active learning experience in many schools of architecture within universities. We would therefore argue that Kolb's experiential learning cycle (Kolb, 2014) in its revised form (Morris, 2020) provides a sound theoretical lens to describe the architectural studio:

"...consists of contextually rich concrete experience, critical reflective observation, contextual-specific

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abstract conceptualization, and pragmatic active experimentation." (Morris, 2020, p. 3)

It is in this context new societal challenges must be introduced to architecture students. Overarching concerns of new critical areas such as equality and sustainability force changes to curricula as the necessary knowledge base of future architects expands (Sopeoglou, 2024). As one core consideration, the building industry is currently using too many resources to be in line with agreed global pathways like the Paris Agreement and the Kunming-Montreal Nature Agreement. As a consequence, re-using building materials in accordance with circular economy principles has received much attention (Kanters, 2020; Kirchherr et al., 2017; Sopeoglou, 2024; Wuyts et al., 2022). We assume that one key competency of future architects is prolonging and increasing the benefit-to-society of the existing building stock. To re-think architectural education towards a circular building industry, Norwegian University of Science and Technology (NTNU) has replaced 10 master level electable courses in architecture with a single learning pathway– Circular Studio – that is built from the ground up to combine current knowledge about building transformation, heritage, re-use of materials, energy and emission calculations, analyzing existing qualities like light and color – as well as experimental practices and research to promote an explorative, knowledge-developing practice among students.

As the students work with circularity in this new studio, they are assumed to socially co-shape their architectural preferences with cultural influences from the profession and school, as well as their nearest peers (Wilson, 1996) and this development can be understood both as a professional and personal self-construction (Kararmaz, 2024). These identity shaping processes complement and challenge a multitude of previous perspectives, where some might be more susceptible to amendment or strengthened, while others would be re-buffed. In this context, the students relationship to nature as a foundation for their understanding of sustainability, biodiversity and ultimately circularity in their own profession can be contrasted with a more traditional image of the architectural profession where other values of architectural quality were more prominent.

In this study, we explore the students' current attitudes and views to circularity, existing buildings and the role of architects as well as the change in their perceptions about circularity and their own ambitions as a future architect as a result of completing 22,5 ECTS credits in the new learning pathway. Our focus is specifically on identifying potential changes so that emerging education in circularity can include these aspects into the planning of courses, learning exercises and other student activities. Specifically, we asked the following research questions:

1. Is there a correlation between the students overall environmental attitudes (NEP-15), their impression management (BIDR-IM) and their professional perception when framed with different practices, such as architects role, heritage concerns and new buildings?
2. Do these perceptions change during the course of a semester as they work hands-on with circular projects?
3. What could be relevant concepts and questions to consider when implementing circularity into educational practices in architecture?

We hope that by answering these questions, we can shed light on the design and development of necessary circular learning activities in universities and encourage cultural change among architects and building industry.

2 CONTEXTUAL MEASURES

As understanding the mechanisms of learning circularity in architecture schools are still at infancy, finding societal relations through explorative means is necessary. In this study, we included measures for two central uncertainties that have emerged during the curriculum development discussion for Circular Studio. Firstly, whether the environmental attitude of the student plays a clear role in self-constructing their professional and personal perspectives on architects. Secondly, whether or not the students leaned towards more socially acceptable answers as the questions moved towards more identity critical questions about the role of architects.

2.1 NEW ENVIRONMENTAL PARADIGM SCALE (NEP-15)

Environmental attitudes have been of great concern in their own right, as well as a background variable to better interpret surveys in other topics. While multiple scales and measures exist, three are widely used and only one, the New Environmental Paradigm (NEP) (Dunlap & Van Liere, 1978) scale does this without referring to specific issues that have since become dated (Hawcroft & Milfont, 2010). The original NEP scale has since been revised (Dunlap et al., 2000) and now includes 15 items that measure 5 different facets of environmental attitude (Dunlap et al., 2000; Hawcroft & Milfont, 2010), the version which is used in this study.

2.2 BALANCED INVENTORY OF DESIRABLE RESPONDING - IMPRESSION MANAGEMENT (BIDR-IM)

As the questions in this study explore the students perception of themselves as future architects, it is vital to examine the extent of Socially Desirable Reporting (SDR), i.e. the over reporting of positive behavior and under-reporting negative behavior. The Balanced Inventory of Desirable Responding (BIDR) (Paulhus, 2012) includes two separate subscales, Self-deceptive Enhancement (SDE) and Impressions Management (IM). The latter signifies a bias toward pleasing others, the school and employees administering the survey in this

case. We specifically utilised the 8 IM questions from the BIDR-16 scale proposed by (Hart et al., 2015).

3 METHODS

This study used a two-stage survey design to examine the attitudes of a select group of students. Of the 29 students, 19 (15 female, average age 25, SD = 2.44) answered the first survey in the beginning of the semester, and 19 (13 female, average age 23, SD = 2.74) answered the survey at the end of the semester after teaching was completed. Of these, 10 replies were overlapping, i.e. the same students answered both the first and the second survey to enable before-after analysis. In addition, 3 teachers answered the first iteration of the survey, and 2 teachers answered the second iteration of the survey. These replies were used as a control and validity checks during data processing and statistics exploration but were not included in the final analysis.

3.1 SURVEY DESIGN

The survey consisted of 5 parts. The first part was designed to collect demographics (age and sex at birth), the track they participated in as well as 4 filler questions that were used to generate a unique code for matching before-after replies while ensuring anonymity (letters in first name, left/right handedness, last digit of phone number and first letter of mothers first name). The second and third parts consisted of the NEP-15 scale as well as the BIDR-IM scale randomized within their own respective sections. The fourth part focused on the students' perceptions of buildings and heritage in society, while the fifth part focused on the role of the architects.
Most responses utilised 5-point Likert style responses for agreeableness, apart from BIDR-IM, which uses a 7-point scale and two open questions on architecture actions and positive/negative impacts. The statements about buildings included:

B1. Buildings should use less energy and resources
B2. The built environment is one of the most important things our society should use resources on
B3. Energy efficient buildings are not worth the cost in most cases
B4. Demolition of buildings should be illegal
B5. I think historical buildings are the most valuable buildings we have
B6. I feel connected to my own history when visiting historical buildings
B7. New, contrasting buildings should not be allowed in historical contexts
B8. The government shouldn't spend money on privately owned heritage buildings
B9. We are completely dependent on new roads and buildings
B10. It's better to leave an old building to decay than for it to lose its character in a refurbishment
B11. Each generation needs to design their own, new surroundings as a society
B12. Even if a school building does not work perfectly, we should still use it instead of building a new one
B13. Energy upgrading is more important than authenticity in heritage buildings
B14. We should use existing buildings as long as we can
B15. Material Aesthetics, rather than technical performance, should be prioritised more.
B16. We should re-use as much building materials as possible
B17. I would like to use only old materials in my home
B18. I think using new materials is an important way to show that a building is new
B19. I think using old materials sometimes makes a building look too shabby
B20. I do not think it is safe to re-use materials for structural components

Of these, B2, B3, B8, B9, B11, B13, B18, B19, B20 are negatively worded, i.e. more agreeableness signifies more resource use. The statemens regarding architects as a professional group were:

A1. I think architects are more concerned about heritage buildings than the average citizen
A2. I think architects are fully capable of transforming existing buildings without any additional education
A3. I think architects reduce the quality of existing buildings through their design interventions
A4. I do not think architects are very good at taking care of our built heritage
A5. I do not think architects should work with heritage buildings, but rather leave these to conservationists and experts
A6. I think most buildings around me could be improved by architects
A7. Having the possibility of working with existing buildings is an important criterion for me when looking for job opportunities.
A8. I am quite concerned about ending up in an architecture office that only designs new buildings
A9. I use a lot of effort to educate myself about how to design interventions in existing buildings
A10. I think my future design projects will mainly be new buildings like the ones being designed today
A11. I would rather design a new home for myself than buy an existing home
A12. I think used and old materials are a better starting point for a good design than new products.
A13. I find it difficult to understand if the use of old and used materials are actually better for the environment

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A14. In my design work, the choice of new or old materials is first and foremost be a question about emission savings
A15. I like to do calculations about material quantities and emissions
A16. I feel at loss about the re-use of materials in design projects

In this section, A3, A4, A5, A10, A11, A13, A14 and A16 were negatively worded, i.e. view architects negatively in light of the collective circularity efforts of society. In addition, two open questions were asked regarding the role of architects:

Q1. When you are working as an architect, what actions do you think will have the most positive or negative environmental impact?
Q2. What do you think architects should do to make the biggest positive contribution towards a just, environmentally sound society?

These were included to capture more nuanced perspectives on how the students viewed their role as a future architect. The BIDR-IM scale can be found in Hart et al. (2015), while the NEP-15 scale is detailed in Hawcroft and Milfront (2010). Altogether, the participants answered 68 questions in the first iteration of the survey and 45 in the second iteration of the survey.

3.2 CONDUCTING THE SURVEY

The survey was conducted twice by using nettskjema.no, a Norwegian academic survey portal. The first iteration was opened 1 week after the students started the course (September 2024) at which point they were familiar with the main concepts of circularity, heritage and re-use to answer the questions in the survey. This iteration included all the survey parts. The survey received 3 reminders and was left open for 1,5 weeks to gather replies.
The second iteration was opened 3 days before final course submission (December 2024) and received 3 reminders to submit. In this iteration, the NEP-15 scale, as well as the BIDR-IM scale were omitted.

3.3 INTERVENTION

Circular Studio is a work-in-progress curriculum development course pilot by the department of Architecture and Technology. The course ran during the fall semester of 2024 and combined four previous master-level courses: Building Conservation, Making is Thinking, Light and Color, and Integrated Energy Design. The professors from these four different courses collaborated and established the concept of *tracks*, which can be understood as different areas of perspectives, where each of the professors brought their own area of expertise to the table. The goal was for students to approach the same project from various perspectives, drawing on different academic backgrounds.

Through shared weeks across the tracks, collaboration in a common drawing studio, and open lectures, the aim was to provide students with insights into various working methods and tools for the further development of circular architecture. In practice, collaboration between tracks proved challenging at times, despite working in the same studio spaces and students focusing on the same area. This was mainly due to the limited time available for the students to both explore the depth of their own track perspective as well as engage in the other tracks' activities.

The Circular Studio course started with two intensive introductory weeks, aiming to increase students' knowledge of materials, demonstrate the potential of existing materials as resources, and train students to see the value in existing buildings. Over four days, the students, in collaboration with Ørlandet Municipality and the Circular Studio teaching team, marked, dismantled, and transported a wooden, log-built storehouse from Hårberg in Ørlandet to Vipetangen in Brekstad center. Additionally, a material catalog of the storehouse was created. This documentation formed the basis for a 3-day task, where students were asked to transform the relocated storehouse into a seaside sauna/bathhouse. Using the knowledge they had gained from the fieldwork, the students developed different project proposals for the new seaside sauna/bathhouse.

The knowledge gained during these intensive weeks was intended to be carried forward into the various tracks. Two of the tracks continued to focus on Ørlandet, one of them working on empty, abandoned, and historically valuable farmhouses that were planned to be moved to a new neighborhood in Ørlandet. The other track worked on reconstructing the storehouse, where students learned a new type of traditional craftsmanship. The two remaining tracks worked on sites in Trondheim. This difference in site and tasks contributed to a span in approaches but was also perceived as an organizational challenge in collaboration between tracks.

The final course projects were presented in December 2024 as a collaborative session between all the tracks. The projects clearly showed different approaches to circularity and the students, together with teaching staff, discussed the implications of these perspectives, lessons learned between tracks and alterations to Circular Studio for future iterations.

3.4 DATA PROCESSING OF RESPONSES

Both iterations of the survey received the same data processing steps:

1. Generate a unique code for each participant
2. Map the Likert responses to numeric values
3. Change direction of negatively worded questions
4. Checks for statistical assumptions, data exploration and sanity checks

5. Omit teacher scores
6. Calculate the scores for NEP-15 and BIDR-IM (first iteration of survey only)
7. Combine iterations for third dataset in perception change (N=10)

This resulted in 4 datasets available for the study: First iteration of the survey, including NEP-15 and BIDR-IM (N=19), second iteration of the survey (N=19), a dataset for the change between iterations (N=10) and a text response dataset for the two open questions from both iterations (N=68).

3.5 ANALYSIS

The analysis must consider several limitations and assumptions, even for an explorative study that is mainly focused on identifying concepts and questions for future use. Since the surveys utilise Likert scales with 5 or 7 items, the resulting variables are ordinal, and this limits the selection of statistical analytical methods. Kolmogorov-Smirnow and Shapiro-Wilk tests of normality on the first iteration of the survey shows that topic-level questions are normally distributed, but individual questions vary. Given the small sample size of each iteration and before-after data, normality was also assessed by viewing the histograms of each item and score. We conclude that overall, the results seem normally distributed, but due caution, we select analysis methods that are robust towards small violations in assumptions about normality. In addition, the selected methods are based on their robustness when dealing with small sample sizes. The responses show weak internal consistency of Cronbach's Alpha, with the exception of NEP-15 (see table 1). This is to be expected as the building and architect question sets are not developed as scales, but rather exploratory questions.

Table 1: Cronbach's Alpha reliability score for sets

Question Set	Cronbach's Alpha
BIDR-IM	.598
NEP-15	.798
Survey 1, Buildings	.406
Survey 1, Architects	.517
Survey 2, Buildings	.452
Survey 2, Architects	.462

An exploratory principal component (PCA) analysis shows that the buildings and architects question sets have 5 and 8 underlying components that explain over 5% of the variation, respectively, in the first iteration of the survey, and 7 components each in the second iteration of the survey. Both the Cronbach's Alpha and the PCA confirm that any assumptions about underlying scales in the questions sets is premature and that identifying individual questions that indicate change should be a priority at this stage of understanding perspective changes in circularity education.

3.5.1 NEP-15 and BIDR-IM correlation analysis

We calculated the Spearman's rank correlation coefficient to examine the correlation from NEP-15 and BIDR-IM to each of the survey questions in the first iteration of the survey. Three significant ($p<.05$, 2-tailed) correlations for NEP-15 and two significant ($p<.05$, 2-tailed) correlations for BIDR-IM were found.

3.5.2 Before-after analysis of Likert scales

To examine the change in perceptions for the 10 students that answered both iterations of the survey, we utilised both a Sign Rank test and a Wilcoxon matched-pair signed rank test. The latter assumes an underlying, hidden, continuous scale for the Likert responses and therefore includes magnitudes of change, while the former produces a more conservative result by only examining the rank and direction of responses without any assumptions about magnitude. Both tests are non-parametric and make no assumptions about normality.

Only one of the tests between iterations revealed a significance of $p<.05$ (2-sided), an expected outcome, given the small sample size, N=10. A ranking of the questions based on significance scores was used to identify the questions most likely to capture changes. This resulted in 4 questions evident with both test methods ($p=.109$ to $.250$ in sign rank test and $p=.043$ to $.221$ in Wilcoxon test), of which 1 was negatively correlated to the assumed direction of the question. In addition, the Wilcoxon test resulted in 7 additional questions of $p<.26$ that were noted.

Also noteworthy, the Sign rank test revealed 15 questions and the Wilcoxon test 3 questions with a significance of 1, which would indicate a completely random change in the responses.

3.5.3 Before-after analysis of written responses

The two open field questions were included in both iteration of the survey: *When you are working as an architect, what actions do you think will have the most positive or negative environmental impact?* (Q1) and *What do you think architects should do to make the biggest positive contribution towards a just, environmentally sound society?* (Q2). The written responses to these questions were analysed in NVivo using a coding of positive and negative aspects, as well as categorisation for the first question, and a categorisation of responses for the second question. To determine changes in perspectives, the analysed lists were compared to identify new elements or change in weights. This part of the analysis did not use code linking of responses (N=68) but examined the entire student group (N=29) for each iteration of the survey and individual statements were coded multiple times, i.e. a statement can be coded as both a positive action and focusing on old buildings. In total, 191 elements were coded across 3 areas: positive and negative impacts (N=56), opportunities and barriers (N=44) and topics (N=91).

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4 FINDINGS AND DISCUSSION

The collected data supports the exploratory phase of identifying concepts and questions and provides insights into potential future development.

4.1 ENVIRONMENTAL ATTITUDES AND IMPRESSION MANAGEMENT

Hawthorne and Milfront (2010, Appendix 1) report a mean score of 3.79 across 51 NEP studies when only considering student participants. These studies range from 1992 – 2006 and it is safe to assume that environmental attitudes have changes since then as public consciousness on sustainability has increased. In comparison, the 19 students that answered the first survey including the NEP-15 score, scored on average a similar 3.89 score (N=19, min. 3.27, max. 4.80, SD=.377). This indicates that the students have a high, but representative pro-environmental attitude.

When comparing the NEP-15 scores to the questions about buildings and architects, three questions (Table 2) show a significant correlation.

Table 2: Descriptive statistics and significant correlations (Spearman's rank correlation coefficient) with NEP-15 for the survey questions of buildings and architects.

Question	Correlation	Sig.	SD	Score $\bar{x}$
B6	.621	.005	.74	4.11
A7	.596	.007	1.03	3.95
A8	.602	.006	1.07	3.63

In relation to environmental attitude, the statement *I feel connected to my own history when visiting historical buildings* (B6) could be interpreted to tie into a general awareness of the role of historical buildings as part of a sustainable environment, i.e. they are already built. This might further tie into the concerns of ones own role in aiding and abiding the continued high use of resoureces when considering statements A7 and A8, which both reflect different aspects of working as an architect and making decisions about resource use. Specifically, A7 and A8 show that the students with an environmentally concerned attitude might let this influence their work decisions if an architectural office is perceived to be working against their enviromental convictions.

Hart et al. (2015, table 1) report 4 values for BIDR-IM scores, with a range from 3.65 to 4.59 in mean scores, but with individual scores spanning the entire range. Our scores are comparable (N=19, mean = 4.36, min. 2.88, max. 6.00, SD=.946). When looking at the correlation between individual questions and the BIDR-IM scores (Table 3), two statements, A7 and A14, are significantly ($p<.05$) negatively correlated, while one statement, B10, is not significant ($p=.12$) but warrants discussion for its positive correlation.

Table 3: Descriptive statistics and significant correlations (Spearman's rank correlation coefficient) with BIDR-IM for the survey questions of buildings and architects.

Question	Correlation	Sig.	SD	Score $\bar{x}$
B10	.504	.028	1.06	2.00
A9	.463	.046	.765	3.84

The positively correlated statement *It's better to leave an old building to decay than for it to lose its character in a refurbishment* (B10) is a value laden statement. It is therefore fair to assume that while students might be at unease about the way in which they shift in this question, they would likely give more definitve answers should the students be presented with a concrete case to evaluate and to do evaluation as part of professional practice.

The other statement*, I use a lot of effort to educate myself about how to design interventions in existing buildings* (A9) is also a very relative question as it does not say anything about actual time used, just perceived effort. While some students might be exaggerating their efforts, others might simply have a feeling of "not learning enough" or simply have different notions of what a lot signifies.

The average signifigance between the individual questions and BIDR-IM correlations is .415, a very high number. This indicates that the students replies are not subject to impression management and are represent true and faithful responses. This is likely also influenced by the use of coupling codes to link the two iterations of the survey in such a way that full anonymity is guaranteed.

Exploring the relationship between the survey statements together with the established NEP-15 and BIDR-IM scales, few aspects seem to be influenced by overall environmental attitudes or the need for impression management. A reasonable assumption is that for some of the students, their environmental attitudes might influence theit choice of workplace, given the opportunity to choose freely.

4.2 PERSPECTIVES AND CHANGE

Ten students answered both iterations of the survey, consisting of 36 questions in each iteration. This resulted in 720 responses that can be analysed. Of the 36 statements in total, 11 had a positive change over .2 points from iteration 1 to 2, while only 3 had a negative change above .2 points (B15, B19 and A14). 22 had only small changes below .2 points. The overall means increased with 4.3 points or an average of .12 per question. There are therefore indications of slight positive tendency between the iterations overall. The Sign Rank and Wilcoxon Matched-pair Signed Rank tests identified 3 questions that had significant positive changes and 6 that had small changes that warrant more exploration.

The statement *Buildings should use less energy and resources* (Question B1, 1. Survey mean 3.7, SD=1.06; 2. Survey mean 4.4, SD=.7; Change=.7, SR sig=.219, T=1.225, WMPSR sig.=.221, T=1.225) indicates that the students increased their awareness of the role of buildings in both energy and resource use, although it seems many students were well aware of this during the first iteration and the change in scores is mainly due to the students who disagreed with the statement shifting their perspective. This is indicated by the min value shifting from *strongly disagree* to *neutral*. Five students had a positive shift on this statement, while only 1 had a negative shift.

The biggest change is found in the statement *Each generation needs to design their own, new surroundings as a society* (Question B11, 1. Survey mean 2.2, SD=1.23; 2. Survey mean 3.8, SD=1.03; Change=1.6, SR sig=.109, T=1.581, WMPSR sig.=.043, T=2.019). This question is negatively worded, signifying that the students alloted less importance to the newness of their surroudnings as they participated in the course. This could indicate a growing awareness of the potential of existing buildings and a growing appreciation of them for 8 of the students while the remaining 2 had a negative shift to the statement.

The final statement with a clear indication of change, *We should use existing buildings as long as we can* (Question B14, 1. Survey mean 4.4, SD=0.7; 2. Survey mean 4.9, SD=.32; Change=.5, SR sig=.125, T=1.500, WMPSR sig.=.059, T=1.890), has an increase from an already very high score that might indicate verifying already held strong beliefs. This shift is due to 4 students regarding the statement more positively. This statement also combines the sustainability and architectural quality narratives, being in favor of contributing to sustainability with a long lifespan while at the same time ensuring that the work of architects (of undescribed quality) is given a long-lasting place in society. It is therefore a win-win statement that seems easy to agree with, but also disregards the operational costs of a building in use.

The other 6 questions that showed small changes (B6, B9, B13, A1, A13 and A15) indicate nuanced shifts concerning energy upgrading and existing buildings in general, architects concerns as well as raised understanding of the technical necessities of working with existing buildings.

In total, there were 104 positive shifts and 78 negative shifts to the statements, indicating a change in perspective that allots a larger role on existing buildings in society and more awareness about the resource use of buildings, see Table 4 for an overview.

Table 4: Descriptives and changes in statements between the first and second iterations of the Survey.

Q	+	-	1. $\bar{x}$	1. SD	2. $\bar{x}$	2. SD	$\bar{x}$ change
B1	5	1	3.70	1.06	4.40	0.70	0.70
B2	1	2	2.40	0.84	2.30	0.82	-0.10
B3	2	3	3.20	0.79	3.20	0.92	0.00
B4	1	1	3.00	0.94	3.10	0.99	0.10
B5	3	1	3.30	0.68	3.50	0.71	0.20
B6	5	2	4.00	0.67	4.30	0.48	0.30
B7	3	3	3.40	0.84	3.40	1.27	0.00
B8	2	1	3.70	0.95	3.90	0.74	0.20
B9	4	1	3.50	0.71	3.80	0.92	0.30
B10	4	3	1.80	0.79	2.10	1.20	0.30
B11	8	2	2.20	1.23	3.80	1.03	1.60
B12	2	3	4.20	0.79	4.10	0.32	-0.10
B13	2	0	3.00	0.47	3.30	0.82	0.30
B14	4	0	4.40	0.70	4.90	0.32	0.50
B15	1	4	3.60	0.84	3.30	0.82	-0.30
B16	3	1	4.70	0.48	4.90	0.32	0.20
B17	2	5	3.00	0.67	2.80	1.03	-0.20
B18	2	4	4.50	0.71	4.40	0.52	-0.10
B19	0	3	4.20	0.63	3.90	0.57	-0.30
B20	3	1	4.20	0.63	4.40	0.52	0.20
A1	3	2	3.10	1.20	3.60	0.84	0.50
A2	2	1	2.50	0.85	2.40	0.97	-0.10
A3	2	2	3.70	0.82	3.60	0.52	-0.10
A4	2	2	3.30	0.68	3.10	0.88	-0.20
A5	1	2	4.50	0.53	4.40	0.52	-0.10
A6	2	4	4.00	0.67	3.80	0.42	-0.20
A7	2	2	3.70	1.16	3.80	1.03	0.10
A8	3	2	3.30	0.95	3.30	1.16	0.00
A9	2	4	3.80	0.63	3.60	0.84	-0.20
A10	5	2	3.60	0.84	3.80	0.92	0.20
A11	3	3	4.00	0.94	3.90	0.99	-0.10
A12	5	2	3.40	0.84	3.60	0.70	0.20
A13	3	1	3.80	0.79	4.10	0.88	0.30
A14	2	4	3.10	0.74	2.70	0.68	-0.40
A15	4	1	2.50	1.27	2.80	1.32	0.30
A16	6	3	2.90	1.10	3.20	1.32	0.30

4.3 PERCEIVED IMPACTS AND ACTIONS

The open questions yielded 68 responses across the study. Focusing on perspectives and concepts using explorative coding, 3 dimensions were identified.

Firstly, the survey explicitly asks for positive and negative impacts, naturally giving the initial dimension. The positive responses from iteration 1 show that the students already have a good grasp of sustainability and can describe these in relation to their own profession. They also naturally include many distinct actions, such as re-use of buildings and materials. The negative actions almost uniformly focus on resource waste, either as not designing for a long enough lifespan, not prioritising quality or building a new building altogether. An interesting aspect is that some responses distinctly raise building budgets as a culprit, making "*only thinking about*

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the short-term cost of a project" (participant) a negative impact, although this is largely thought to be outside the sphere of influence of the architects (although it seems sometimes used as an excuse for less-than-optimal architectural work). The responses to the second iteration of the survey shows a clear change in perspective. Only one response in the first iteration brought up being an agent of change:

"Working in teams with people from multiple fields knowledge and constantly making sure to be working in a way that is open to explore new methods is very important towards making a positive environmental impact." (Participant)

Contrastingly, the second survey revealed 4 responses that focus on this aspect as an avenue to positive impact, although actions on individual design decisions are still prevalent. The responses focusing on negative impacts also revealed what might be a growing awareness of one's own role, highlighting business-as-usual for the architectural profession in somewhat stark terms:

"Less ego, less starchitects, less visibility. Less is more. More anonymity, discretion and care for context." (Participant)

"Any building is a negative environmental impact, less work is less environmental impact, simple." (Participant)

"Everything that leads to overconsumption." (Participant)

Secondly, responses overwhelmingly focus on opportunities (N=41) over barriers (N=3). Interestingly all barriers are attributed to others (clients, laws and people experiencing the architecture), a somewhat un-critical stance. As opportunities, learning and evolving is prevalent in the first iteration, as well as changing the norm:

"The role of an architect is not the same as it was just a couple of years ago." (Participant)

It seems clear that the students are well aware of the changes in the profession as the knowledge base expands but the responses clearly indicate that the necessary change is still in the future and that they are yet to reach it. In the second iteration, a new notion is identified. Listening to others, as opposed to many responses viewing the work of architects as more of a one-way communication for the betterment of society, is stated. It seems that the students are still overwhelmingly focused on the contributions of the architect and see themselves as being in the forefront of change but the responses in the second iteration show that this perception might be changing among few of the students during the course.

Thirdly, individual professional and process topics were identified. Building topics included well documented aspects within environmental sustainability, such as new vs old buildings, re-use or virgin materials and building lifespan. When describing building aesthetics, a more diverse set of responses emerged. It seems aesthetics are considered almost universally important and thought to also affect the lifespan of the building through attractiveness, but the relationship between technical aspects and aesthetics is seen as potentially opposites by some. It is still clear, however, that the students view aesthetics as a core contribution to sustainability from architects:

"When it is necessary to build something new, it should be built to last hundreds of years, and be so beautiful that people will protect it and take care of it" (Participant)

Some actions focus more on processes related to the design, rather than the design itself. Between iterations, two perspectives show a large change. The students increasingly mention teamwork as well as an increased need to supplement their own learning. This might indicate a growing understanding of the complexity of circularity and therefore the need to seek knowledge both through interdisciplinarity as well as self-study.

In sum, the two open questions imply that the students have a sound (and sometimes critical) understanding of the relation between their own profession and its inherent challenges with regards to sustainability and circularity. During the course, this understanding seems to develop from a solution-oriented towards more process- and collaboration-oriented.

4.4 SUMMARY OF FINDINGS

To construct a coherent narrative of findings, we would argue that the students are environmentally conscious and have a good grasp of the inherent sustainability challenges of being a business-as-usual architect, working on new buildings with virgin materials and little concern for energy use. They are critical about the architect's contribution into overuse of resources which they seem to perceive as an impending shift within the profession, but one that is still in the future. They see clear opportunities for win-win solutions, especially combining aesthetics with technical knowledge to extend building lifespan. These attitudes might influence career choices as they increasingly see themselves as agents of change as they participate in Circular Studio. This manifests itself in increased awareness about the role of existing buildings as an opportunity for sustainable designs, but also in viewing others initially as barriers to sustainability, but shifting into appreciating multiple, cross-disciplinary perspectives and an increased focus on their own learning needs. From the data, we have explicitly identified the following perspectives and concepts:

1. The student's critical perception of architects as a contributor to non-sustainable practices by designing new buildings with virgin materials
2. The perceived win-win opportunities of aesthetic quality and increased lifespan of buildings.
3. The shift from solution-oriented to process- and collaboration oriented as learning about circularity.
4. Increased self-perception as agent of change.
5. Perceived increase in need to learn more about sustainability while learning.

5 IMPLICATIONS AND LIMITATIONS

Implementing circularity into studio based courses in architectural education seems to support experiential learning (Kolb, 2014; Morris, 2020). We see clear indications of the students learning concepts, approaches and frameworks that are then used to re-frame, reject and amend personal and professional identity in self-construction (Kararmaz, 2024). The 5 identified concepts and perspectives can be seen as different manifestations of this learning process. It is however clear that the sample sizes, exploratory questions and limited case in this study is far from providing sufficient evidence for systematic conclusions. It is therefore vital to support a continued research effort and exploration alongside circular learning activities. There are clear indicators, and it is also the subjective opinion of the authors, that a continuous development of measures to examine the perception change in students as they are increasingly introduced to circularity in architectural education can be immensely valuable to support developing curriculum.

Should the research community be able to identify and hone precise and dependent measures for students' perception of circularity in their own design practice and beyond, a significant contribution could be made. Specifically, developing courses that not only include the systematic complexities and multitude of perspectives of circularity, but also ensure that students can actively use this learning to develop their architectural knowledge, values and approaches.

For these reasons, we recommend that architecture schools looking to implement circularity into their curriculum ensure their studio setting, course description and practical teaching support experiential learning principles and that they implement a before-after measure, interviews or other, replicable, evaluation methods that specifically target the 5 identified concepts and perspectives, but also try to modify them and uncover additional perspectives that should be published. Additionally, researchers should strive to develop coherent scales of questions for any identified perspectives and concepts and verify these through the means of statistical tools such as principal component analysis. In this way, the community can begin solidifying a more coherent and comprehensive evidence base to support the necessary introduction of circularity into architectural education.

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