IDENTIFYING AND VALIDATING SUSTAINABLE DEVELOPMENT GOALS-RELATED KEY COMPETENCIES IN UNDERGRADUATE GRAPHIC DESIGN EDUCATION

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Abstract

In contemporary higher education, aligning student competencies with sustainable development goals (SDGs) is crucial for enhancing their employability. This necessity extends to graphic design undergraduate programs, pivotal in nurturing designers capable of addressing global sustainability challenges. Using a mixed-methods approach, this study aims to outline essential competencies for graphic design undergraduates pertinent to the SDGs. The research commenced with a systematic review of fourteen seminal articles, leading to the initial identification of fifty-eight key competencies. Subsequently, a Delphi study involving 44 graphic design experts validated these competencies. This iterative process refined the list, excluding twenty-seven competencies and affirming thirty one as critical. These validated competencies were categorized into four groups: Systemic, Performance, Contextual, and Global. The study's findings provide valuable insights for graphic design educators and industry employers, illuminating competencies essential for addressing sustainability challenges. Furthermore, this research contributes to academic discourse by offering a structured framework for integrating SDG-related competencies into graphic design education. This facilitates the development of designers proficient not only in their craft but also in sustainability imperatives. Our aim is to enhance pedagogical strategies and inform curriculum development in graphic design education, aligning them with evolving professional demands and sustainable development objectives.
Keywords: *key competencies, SDG, design education, sustainability, Delphi method, systematic review, graphic design*

Introduction

In contemporary higher education, the imperative for institutions to train students with competencies that align with sustainable development (SD) has been increasingly recognized as critical for enhancing their employability, responsiveness to sociocultural shifts, and adaptability to technological progress. This has been particularly salient in undergraduate design education, where the traditional paradigms of design practice have been critically reevaluated in light of the exigencies of sustainable societal transformation (Manzini et al., 2001). The evolving landscape has necessitated the cultivation of designers' competencies not only in aesthetic and functional innovation but also equipped to address the multifaceted challenges of sustainability (Vezzoli & Manzini, 2008).

Agenda 2030's focus on sustainability (UN, 2015) highlights resource management's importance, making circular economy a key solution (Ellen MacArthur Foundation, 2012). Though its definition evolves (Korhonen et al., 2018), core principles like closed-loops are shared by cradle-to-cradle design and industrial ecology (Graedel & Allenby, 1995; McDonough & Braungart, 2002). The Ellen MacArthur Foundation's influential definition positions CE as an economic system focused on restoration and regeneration (2012).

SDG 12, "Responsible Consumption and Production," is a pillar of the UN's 2030 Agenda for Sustainable Development (UN DESA, n.d). It aims to shift global consumption and production patterns towards sustainability, recognizing the environmental and societal harm caused by current practices in developed nations. By promoting responsible choices by individuals and corporations, SDG 12 fosters a healthier planet and a sustainable global economy.

Over 20 years ago, the World Academies of Science made a strong statement urging that science and technology be used to drive a global shift towards sustainability (IAP, 2000). Despite technological advancements, progress towards sustainability is hampered by deficient global education. Education, especially in science and social sciences, underpins innovation and economic productivity. It equips individuals to navigate a changing job market, securing employment and improving their quality of life. The scientific community plays a vital role. Natural and social sciences must be the core curriculum, and collaboration between scientists and educators is crucial for engaging science education. Scientists are united in their calls for urgent changes to human activities in order to halt the degradation of the natural environment (Ripple et al., 2020).

Shifting legal, market, and financial pressures push manufacturers to develop and market sustainable products. Product life cycle impacts depend on interactions with social, economic, and technical systems. Businesses, especially established ones, can drive change through design and communication (Gutterman, 2023)

Community engagement is vital for service design to drive social innovation. Designers bring specific skills to co-create solutions with communities, addressing local challenges and opportunities (Manzini & Jégou, 2008). Understanding this context is key, as successful service design requires a human-centered, transformative approach (Karpen et al., 2017)

Spangenberg et al. (2010) argued design is crucial for achieving satisfaction with sustainable practices. They propose that design's full potential is unlocked only through a sustainability lens (p. 1492). This suggests educating designers in sustainability principles is essential to fulfilling design's philosophy, mirroring the circularity found in nature for millennia. Moreover, the discipline of design for sustainability has emerged, and as Vezzoli et al. (2018) write “in its broadest and most inclusive meaning could be defined as a design practice, education, and research that, in one way or another, contributes to sustainable development.”

Design education in the 21st century necessitates a critical reevaluation to prepare future designers for a dynamic and multifaceted landscape. This transformation must encompass not only an aptitude for evolving technologies but also a profound understanding of social issues, human behavior, and contemporary business models. Furthermore, designers must navigate novel ethical challenges arising from expanding into diverse global territories with distinct sustainability concerns, cultural contexts, and value systems (Meyer & Norman , 2020).

The findings of this study have implications for both graphic design educators and employers. This article contributes to knowledge in two ways: (1) synthesize and systematize results from previous studies on the competencies of designers needed in the new context and challenges of sustainability; (2) key competencies required that undergraduate students studying design must possess to meet the challenges of Systemic challenges, Performance challenges, Contextual challenges and Global challenges. This research is important for design schools, educators, as well as design students. It clarifies what is desired and achievable by clearly identifying which competencies are appropriate for each individual.

The significance of this research extends beyond academic discourse and offers pragmatic insights for graphic design educators and industry employers. By elucidating the competencies required for sustainability-focused design practice, this study contributes to the redefinition of design education, advocating for a curriculum that not only equips students with the technical and creative skills pertinent to their discipline but also imbues them with the knowledge and values essential for fostering sustainability. Thus, this research plays a crucial role in shaping the future of design education, ensuring that the next generation of designers is prepared to meet the challenges of a rapidly evolving and increasingly complex global landscape.

Literature review

Evolving Paradigms of Sustainable Development: An Imperative for Design

Since the 1970s, concerns about resource depletion and environmental degradation have spurred the rise of Sustainable Development (SD). Early works like Malthus's population theory (Coomer, 1979) and Meadows' "Limits to Growth" (1972) highlighted resource constraints. Later, Daly (1992) and Basiago (1996) emphasized managing growth and environmental concerns. Today, SD encompasses economic, social, and environmental dimensions, aiming for balance and equity (Taylor, 2016). Key challenges include resource constraints, pollution, and climate change (Basiago, 1996, 1999). Mounting evidence necessitates a fundamental shift in human behavior towards sustainability. This demands reevaluating underlying assumptions, beliefs, and frameworks that guide our actions (Rieckmann, 2017). Recognizing the interconnectedness with nature, humanity, and the wider impacts of individuals' actions is crucial (Department of Economic and Social Affairs - UN, 2016).

From Eco-Design to Sustainable Development Goals: A New Directive for Designers

The emergence of *Design for Environment* (Fiksel, 1995) and *Eco-Design* (Brezet & Hemel, 1997) represents a pivotal shift towards embedding sustainability across product life-cycles. This shift, while monumental, is but a precursor to the larger and more ambitious goals outlined in the United Nations Sustainable Development Goals (SDGs). These goals, particularly as analyzed by Kanie and Biermann (2017), extend an open invitation—and indeed, a challenge, to the design community: to innovate within the constraints of sustainability, to redefine problem solving through a sustainable lens, and to actively contribute to the global sustainability agenda.

Education in Change: The Role of Sustainable Design

Central to realizing the vision of sustainable design is the overhaul of design education itself. The emphasis of the 2030 Agenda on Education for Sustainable Development (ESD), as encapsulated by SDG4, heralds a new era of design pedagogy. This transformative education, as advocated by UNESCO (2017), is not merely about imparting knowledge but about fostering a generation of designers who are critical thinkers, problem solvers, and sustainability champions. The collaborative networks and partnerships mentioned by Mulà et al. (2017) exemplify the collective effort needed to embed ESD within design curricula globally.

Competency-Based Education: Bridging the Gap Between Theory and Practice

The dialogue on "competency" in design education, inspired by pioneers like Hamel and Prahalad (1994) signals a departure from traditional educational models towards a more dynamic, skills-oriented framework. However, this competency-based approach necessitates a radical rethinking of curriculum design to address the "Performance", "Systemic", "Contextual" and "Global" challenges of contemporary design practice, as critiqued by Friedman (2019). The current state of design education, while making strides towards sustainability, often falls short in equipping students with the comprehensive skill set required to navigate and influence the complex, interconnected systems of the modern world.

This review underscores an urgent need for a paradigmatic shift in design education toward sustainability, recognizing the integration of SD principles into design curricula not as an option but as a moral imperative. In the face of global environmental challenges, the design community is called upon to adopt a transformative educational model that equips future designers with the required knowledge, skills, and critical thinking abilities. The journey ahead is fraught with challenges but offers a unique opportunity to redefine the essence of design in forging a sustainable future. This narrative, shaped by both historical and contemporary analyses, serves as a clarion call for a necessary evolution in design education, setting a new course towards sustainability.

Research Methodology

General Background

This research embarked on a nuanced exploration of the essential competencies required by designers to navigate the evolving landscape of sustainability challenges. Adopting a mixed-methods methodology, the study meticulously combined secondary and primary data sources to attain a holistic understanding of the competencies that align with sustainability standards. Thus, this study began with a systematic review of the literature, carefully analyzing 14 seminal articles to distill 58 critical competencies deemed essential for contemporary design challenges (Step 1). Subsequently, a Delphi study was employed involving 44 experts - comprising 32 academic scholars and 12 industry professionals - to validate these competencies, ensuring the validity (Step 2).

Step 1: A Systematic Review of Previous Studies

The employment of systematic analysis in this study represents a bibliometric exploration of the extant literature, aiming to identify influential trends and seminal works within the domain of design education and sustainability. This step aims to explore bibliometrics indicators like citations, keywords, authors and so on. Such an approach has been utilized in numerous disciplines, notably in "business, management, and accounting," "economics, econometrics, and finance," and "social sciences" (Broadus, 1987; Pritchard, 1969; Wallin, 2005).

Specifically, using the Web of Science and Scopus databases, we conducted a search query using related keywords as follows: *21st century, design education, competency framework, circular economy, and sustainable development* with the aim of collecting the initial data. Thus, 628 documents were obtained at this step. Next, the researchers read thoroughly the abstracts of these 628 documents in order to identify the papers focusing specifically on designer competencies for sustainable development. After this step, 42 documents were identified. Next, another round of screening of these 42 documents was adopted as we read carefully the full texts of these 42 documents. Eventually, we obtained 14 documents which would be used for systematic content analysis (see Table 1). The aim of content analysis is to figure out a list of 58 competencies necessary for sustainable graphic designers. These 58 competencies were grouped into four types of challenges faced by sustainable graphic designers according to (Meyer & Norman, 2020) (see Table 4).

Table 1
List of Key Papers On Graphic Designer Competencies For Sustainable Development

No	Authors	Title	Journal	Year of publication
1	Simon O'Rafferty, Hannah Curtis and Frank O'Connor	Mainstreaming Sustainability in design education – a capacity building framework	International Journal of Sustainability in Higher Education	2014
2	Watkins M., Casamayor J.L., Ramirez M., Moreno M., Faludi J., Pigosso D.C.A.	Sustainable Product Design Education: Current Practice	She Ji: The Journal of Design, Economics, and Innovation	2021
3	Sumter D., de Koning J., Bakker C., Balkenende R.	Key Competencies for Design in a circular economy: Exploring the gaps in design knowledge and skills for a circular economy	Sustainability	2021
4	Freitas A.P.N.D., Almendra R.A.	Soft skills in design education, identification, classification, and relations: proposal of a conceptual map	Design and Technology Education: An International Journal	2021
5	Noël G.	Fostering Design Learning in the Era of Humanism	She Ji the Journal of Design Economics and Innovation	2020
6	Weil D., Mayfield M.	Tomorrow's Critical Design Competencies: Building a Course System for 21st Century Designers	She Ji: The Journal of Design, Economics, and Innovation.	2020
7	Meyer, M.W., Norman, D.	Changing Design Education for the 21st Century	She Ji: The Journal of Design, Economics, and Innovation.	2020
8	Sumter D., de Koning J., Bakker C., Balkenende R.	Circular economy competencies for design	Sustainability	2020
9	Ostergaard T.	Decoding Sustainable Competencies and didactics in design education	The 22nd International Conference on Engineering and Product Design Education	2020
10	Moreira M.	Making Design Education (Even More) Complex: Exploring Complexity for an Amplified Mindset of Design	The International Journal of Art & Design Education	2019
11	Haug A.	Educating ethical designers	International Journal of Technology and Design Education	2017
12	Casais M., Christiaans H., Almendra R.	Sustainability curricula in design education	International Conference on Engineering and Product Design Education	2012
13	Wiek A., Withycombe L., Redman C.L.	Key competencies in sustainability: A Reference Framework for academic program development	Sustainability Science	2011
14	Trimingham, R., Lofthouse, V., Norman, E., Bhamra, T., Zanker, N.	An integrated approach to sustainable design education	International Conference on Engineering and Product Design Education	2008

Step 2: A Delphi Study

Panel Selection

Critical to the Delphi technique's efficacy is the deliberate selection of an expert panel, tailored to address questions characterized by high levels of uncertainty and speculation (Okoli & Pawlowski, 2004). The process of participant selection is paramount, influencing the study's relevance and success significantly (Clayton, 1997; Franklin & Hart, 2007; Gordon, 2003; Skulmoski et al., 2007). An "expert" within this context is someone endowed with the requisite knowledge and experience to contribute meaningfully to the Delphi process (Clayton, 1997).

For this study, 44 experts in the field of Design, comprising 32 lecturers and 12 education experts, with 68.2% possessing experience ranging from 6 to over 20 years, were invited to participate in the Delphi rounds. This diverse panel was selected to gather a broad spectrum of insights and experiences related to curriculum development, teaching methodologies, and management within design education and its emerging challenges and trends. Communication with experts was facilitated via email, and responses were collected through an online platform.

These 44 experts were recruited in a convenient manner as all of them are colleagues of one of the co-authors of this paper. According to McKenna (1994), in the Delphi study, the panel of experts is recommended to have close connections with researchers in order to ensure high retention after successive rounds. Initially, 70 eligible experts were invited to join the study, and 44 of them agreed. According to Endacott et al. (1999), the number of participants in a Delphi study should be between 20 and 50. Thus, our number of 44 experts is satisfactory.

Consensus Process

The study achieved consensus after two rounds of the Delphi process. The first round involved interviews with 44 experts, while the second round saw the participation of 39 experts. Thus, 88.6% of experts responded in both rounds, indicating a high level of engagement and consensus across the pool of participants (see Table 2).

This rigorous application of the Delphi study underscores its utility in synthesizing expert insights to inform the identification and validation of key competencies required for designers in the contemporary professional and academic setting. The method's systematic approach to soliciting and refining expert judgments provides a robust foundation for developing competency-based educational strategies aligned with current and future demands in the design sector.

Table 2
Profile of Experts in Two Delphi Rounds

	Round 1		Round 2		All rounds *	
	f	%	*f*	%	*f*	%
Professional experience (years)						
< 5	14	31.8	13	33.3	13	29.5
06_10	14	31.8	12	30.8	12	27.3
11_15	7	15.9	6	15.4	6	13.6
15_20	5	11.4	5	12.8	5	11.4
> 20	4	9.1	3	7.7	3	6.8
Highest educational degree						
Doctor of Philosophy (PhD)	5	11.4	3	7.7	3	6.8
PhD Candidate	2	4.5	1	2.6	1	2.3
Master (MA)	33	75.0	31	79.5	31	70.5
Bachelor	4	9.1	4	10.3	4	9.1
Profession						
Lecture	32	72.7	29	74.4	29	65.9
Education Expert	12	27.3	10	25.6	10	22.7
University/ Organization/ Company						
University	44	100	39	100	39	88.6
Organization	0	0	0	0	0	0
Company	0	0	0	0	0	0

Note. All rounds *represent participants who responded to all two Delphi rounds.

Statistical Measures Employed

The primary statistics utilized in Delphi studies encompass measures of central tendency and dispersion, specifically standard deviation and interquartile range. These measures are essential to depict the consensus and diversity of opinions within the respondent group (Hasson et al., 2000). The median and mode are often preferred for their ability to represent the central position of ratings in a non-normally distributed data set, which is common in Delphi studies. The literature strongly supports the use of the median score, particularly with Likert-type scales, to ascertain the intensity of expert agreement or disagreement on a linear continuum (Eckman, 1983; Hill & Fowles, 1975; Hsu & Sandford, 2019; Jacobs, 1996).

Likert-Type Scale Application

Likert-type scales, assuming a linear intensity of experiences ranging from strong agreement to strong disagreement, are widely adopted to measure attitudes within Delphi studies. For instance, a 4-point Likert scale ranging from *Very Important* (4) to *Not Important* (1) is commonly used to gauge expert perceptions. Green (1982) posits that a consensus threshold should be established where at least 75% of participants rate level 3 or 4-point Likert scale, with a median score requirement of 3.25 or higher to indicate agreement.

Stability and Consensus Measurement

Scheibe et al. (1975) argued against the sufficiency of percentage measures alone, advocating for the assessment of response stability across successive rounds as a more reliable indicator of consensus. Stability, or the convergence of panel responses, is achieved when minimal shifts occur from one round to the next, suggesting a reaching of consensus (Murry & Hammons, 1995).

To facilitate this analysis, rating scales are converted to numerical values, and the mean and standard deviation are calculated, excluding non-responses. Typically, a 75% agreement threshold is recommended for consensus on items by the second round or subsequent rounds. The literature does not provide any rigid standards for the consensus, however, every study should define what percentage of the participants' responses will be considered consensus (Murry & Hammons, 1995).

Table 3
Rules For Analyzing The Ratings From Multiple Experts With Delphi Approach

Round t for Delphi questionnaire	Round t + 1 for Delphi questionnaire	Round t + 2 for Delphi questionnaire
Rating_Mean(*qi*) >= 3.25	IF Rating_Mean(*qi*)>= 3.25 and % f(3/4) represents >= 75%, Then *qi* is accepted, and no further discussion concerning *qi* is needed	
Rating_Mean(*qi*) < 3.25	IF Rating_Mean(*qi*)<3.25 and % f(3/4) represents < 75% Then *qi* is rejected, and no further discussion concerning qi is needed	
Rating_Mean(*qi*) < 3.25	IF Rating_Mean(*qi*)<3.25 and % f(3/4) represents >= 75%	Rating_Mean(*qi*) >= 3.25 and Rating_Variant(*qi*) < 15% and f(3/4) represents >= 75% Then *qi* is accepted, and no further discussion concerning *qi* is needed

Source: Green (1982)

Research Results

Results from Systematic Analysis

Following 14 key papers as presented in Table 1, an in-depth reading and analysis of each article were undertaken to identify the essential competencies for sustainable graphic designers. Thus, 58 competencies were figured out and grouped into four challenges (Performance, Systematic, Contextual, and Global) as shown in Table 4.

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Table 4
List of Competencies for Sustainable Graphic Designers Extracted from Literature Review

Code	Competency
A	Performance challenges
A1	Creativity
A2	Critical thinking
A3	Anticipatory competency
A4	Negotiation skill
A5	Commitment to lifelong learning
A6	Leadership
A7	Self-direction/ Self-management
A8	Teamwork
A9	Ethics/compromise
A10	Entrepreneurship
A11	Legislation and regulatory compliance
A12	Visual and verbal communication
A13	Sketching, Modeling, Prototyping, Simulation skills
A14	Designing for multiple use cycles
A15	Sustainable product design methods/ process
A16	Dematerialization, design/component simplification
A17	Research and Exploration
A18	Circular economy understanding
A19	Circular economy communication
A20	Circular business model integration
A21	Understanding cost implications
B	Systemic challenges
B1	Systems thinking and Holistic thinking
B2	Circular systems thinking
B3	Systemic understanding/ System innovation
B4	Knowledge of materials and manufacturing processes
B5	Understand new contexts for design and innovation
B6	Engineering-related knowledge of how the product functions
B7	Failure mode and effects analysis (FMEA) and maintenance methods
B8	Understanding of user behavior, user testing and ethnography
B9	Interdisciplinary design
B10	Design of product-service systems (PSS)
B11	Design of digital circular logistics systems

B12	Design simplifies complicated system perception and description
C	Contextual challenges
C1	Problem solving
C2	Risk taking
C3	Adaptability in work
C4	Decision making and trade-offs in design processes
C5	Empathic user-focused understanding & observation
C6	Data-driven design may help policy and action.
C7	Circular user engagement
C8	Service design process
C9	Circular (reversed) logistics cost and organization
C10	Understand key concepts of sustainable development, including social aspects
C11	Reverse logistics & logistics - supply chain, manufacturing, repair
C12	Understanding of the commercial, institutional, legislative, and social motivations for implementing sustainable development.
C13	Understanding of the concept of sustainable design and how it exists within an industrial context.
C14	The capability to collaboratively analyze complex systems across diverse domains and various scales
C15	Understand how to analyze the environmental profile of a product and generate appropriate improvement options
D	Global challenges
D1	Conscious of environmental, social, cultural, and human issues.
D2	Circular impact assessment
D3	Eco-materials knowledge
D4	Understanding low carbon and resource efficiency
D5	Methods and tools to assess environmental impact: life cycle analysis (LCA)
D6	Eco-design/sustainable product design strategies and application
D7	Understand how to analyze the environmental profile of a product and generate appropriate improvement options
D8	Circular economy and 3R implementation (reduce, reuse, recycle)
D9	Design for X (e.g. recycling, disassembly, re-use, remanufacture)
D10	Have an appreciation of the commercial, institutional, legislative, and social motivations for implementing Sustainable Development.

Results of the Delphi Technique

Delphi Round One

Table 5 delineates the initial assessment of 58 competencies in four challenges, attributing a mean (*M*), Standard Deviation (*SD*), and a categorization outcome - *Accepted, Next Round* or

Rejected - based on expert ratings. These ratings were quantified using a 4-point Likert scale, ranging from *Very Important* (4) *to Not Important* (1), to gauge the relative importance of each competency, according to the expert's opinion.

Table 5
Results of Delphi's Round 1

Challenges	Code	*M*	*SD*	% *f*(3/4)	Results of Round 1
Performance challenges	A1	3.70	0.5	100	Accepted
	A2	3.57	0.5	98	Accepted
	A3	3.11	0.7	84	**Next Round**
	A4	3.25	0.7	93	Accepted
	A5	3.48	0.6	98	Accepted
	A6	**2.82**	**0.8**	**61**	**Rejected**
	A7	3.41	0.7	89	Accepted
	A8	3.25	0.8	82	Accepted
	A9	3.59	0.5	98	Accepted
	A10	**2.61**	**0.8**	**55**	**Rejected**
	A11	3.48	0.7	91	Accepted
	A12	3.45	0.7	91	Accepted
	A13	3.43	0.6	95	Accepted
	A14	3.25	0.6	91	Accepted
	A15	3.25	0.7	86	Accepted
	A16	**2.95**	**0.7**	**77**	**Next Round**
	A17	3.52	0.6	93	Accepted
	A18	**2.86**	**0.7**	**66**	**Rejected**
	A19	2.75	0.7	68	Rejected
	A20	2.64	0.6	57	Rejected
	A21	3.00	0.7	77	Next Round
Systemic challenges	B1	3.52	0.6	98	Accepted
	B2	**2.80**	**0.7**	**73**	**Rejected**
	B3	3.25	0.7	93	Accepted
	B4	3.39	0.8	86	Accepted
	B5	3.36	0.7	91	Accepted
	B6	**2.98**	**0.7**	**73**	**Rejected**
	B7	**2.89**	**0.7**	**70**	**Rejected**
	B8	3.57	0.6	93	Accepted
	B9	**3.11**	**0.8**	**82**	**Next Round**
	B10	**2.98**	**0.6**	**80**	**Next Round**
	B11	**2.82**	**0.6**	70	Rejected
	B12	3.00	0.7	73	Rejected

Contextual challenges	C1	3.68	0.5	98	Accepted
	C2	**2.86**	**0.7**	**75**	**Next Round**
	C3	3.45	0.7	93	Accepted
	C4	3.25	0.7	86	Accepted
	C5	3.48	0.6	93	Accepted
	C6	2.80	0.6	73	Rejected
	C7	2.89	0.7	75	Next Round
	C8	2.91	0.7	73	Rejected
	C9	2.80	0.7	**73**	**Rejected**
	C10	3.27	0.7	89	Accepted
	C11	**2.86**	**0.6**	**72**	**Rejected**
	C12	3.25	0.7	93	Accepted
	C13	3.43	0.6	93	Accepted
	C14	**2.77**	**0.6**	**66**	**Rejected**
	C15	3.30	06	95	Accepted
Global challenges	D1	3.48	0.6	93	Accepted
	D2	**2.93**	**0.6**	**80**	**Next Round**
	D3	**3.23**	**0.7**	**84**	**Next Round**
	D4	**2.80**	**0.8**	**59**	**Rejected**
	D5	**2.91**	**0.7**	**74**	**Rejected**
	D6	3.34	0.7	89	Accepted
	D7	**2.93**	**0.7**	**73**	**Rejected**
	D8	3.25	0.6	93	Accepted
	D9	3.27	0.6	93	Accepted
	D10	**3.07**	**0.8**	**73**	**Rejected**

Note: *N* = 44. Mean *(M)* and Standard Deviation *(SD)* are calculated for a 4-point Likert scale. % *f*(3/4) represents the percentage of respondents rating 3 or 4 on a 4-point Likert scale.

The first Delphi round precipitated a discernible diversity in the assessment of competencies, as evidenced by a spread in mean scores from 2.61 to 3.70. In particular, the competency C*reativity* (*A1*) emerged as paramount, receiving the highest value at 3.70, juxtaposed against *Entrepreneurship* (*A10*), which was evaluated as the least critical, with a score of 2.61.

Of the 58 identified competencies, the consensus was reached on 30, which were subsequently endorsed for this phase. Within this group, 23 competencies were particularly prominent, obtaining scores above 3.4, indicative of a consensus that exceeded 90%. On the contrary, the other 19 competencies did not achieve the requisite consensus for advancement due to their inability to meet the dual criteria delineated in Table 3: specifically, a mean score falling below 3.25 coupled with fewer than 75% of experts giving a score of 3 or 4-point score.

This dichotomy in expert consensus, which approximates 84.5% (49/58 competencies) endorsed or dismissed - underscores a significant alignment among the 44 participating experts in their assessment of competencies. A residual 15.5% of the competencies remained contentious, meeting the criterion of a supermajority exceeding 75% for the top two ratings, yet faltering on the mean score benchmark of 3.25. These nine competencies earmarked for further scrutiny in subsequent Delphi rounds reflect the iterative nature of achieving scholarly consensus.

The initial Delphi round unveiled divergent perspectives among experts on the relative importance of key competencies, with a marked preference for those associated with innate creativity and talent in the design realm. For example, unanimity was observed in the assessment of C*reativity* (A1) competency, with a resounding score of 3.4. This trend continued with high valuations for competencies related to *Sketching, Modeling, Prototyping, Simulation* skills (A13) at 95%, *Design for X (e.g. recycling, disassembly, re-use, remanufacture)* (D9) at 93%, and *Visual and verbal communication* (A12) at 91%.

In addition, competencies that facilitate cognitive development, such as *Critical thinking (A2)* and *Systems thinking and Holistic thinking (*B1), received near-universal acclaim, reflecting a consensus on their indispensable role in contemporary design practice. This recognition extends to competencies enhancing cross-disciplinary understanding and adaptability, underscoring their importance in navigating job-specific demands and future shifts within the field.

Competencies integral to sustainable design also received significant expert endorsement, signifying a collective recognition of their centrality to industry practices. This is exemplified by robust support for *Sustainable product design methods/processes* (A15) at 86%, an *Understanding of the concept of Sustainable Design and how it exists within an industrial contex*t. *(C13)* at 93%, and strategies for *Eco-design/sustainable product design strategies and application* (D6) at 89%.

Interestingly, the competency associated with L*eadership* (A6) was comparatively undervalued, with a mean score of 2.82 and 61% of top-level ratings, culminating in its exclusion in the initial round. This decision aligns with the sector's prioritization of *Teamwork* (A8), which was affirmed by an 82% approval rating, illustrating the nuanced considerations inherent in curating competencies for the evolving landscape of design education and practice.

Delphi Round 2

In accordance with the iterative nature of the Delphi method, competencies not reaching consensus in the initial round were given further scrutiny in the subsequent round. This second phase of the evaluation engaged 39 experts, representing 88.6% of participation as delineated in Table 2, thus satisfying the criteria for the requisite number of expert participants established in Round 1.

Table 6
Results of Delphi's Round 2

Challenges	Code	*M*	*SD*	% f(3/4)	Results of Round 2
Performance challenges	A3	3.13	0.7	79	Rejected
	A16	3.05	0.8	79	Rejected
	A21	2.97	0.9	74	Rejected
Systemic challenges	B9	3.18	0.8	79	
	B10	3.03	0.6	85	Rejected
Contextual challenges	C2	3.08	0.8	82	Rejected
	C7	3.00	0.6	82	Rejected
Global challenges	D2	2.82	0.7	67	Rejected
	D3	3.26	0.7	87	Accepted

* *Note.* $N = 39$. The mean (*M*) and standard deviation (*SD*) are calculated for a 4-point Likert scale. % f (3/4) represents the percentage of respondents who rate 3 or 4 on a 4-point Likert scale.

An analytical review of the data presented in Table 6, juxtaposed with the findings in Table 5, indicated a pronounced consistency in the assessment of competencies in the two rounds. Despite observable fluctuations in the rating variable (*qi*) between competencies, the aggregate mean scores remained predominantly stable. A nuanced analysis aimed at deciphering the evolution of the ratings of each expert between the two rounds was carried out. The results, cataloged in Table 7, detail the expert reviews in Round 2. Of particular note was the competency in e*Eco-materials knowledge* (*D3)*, which uniquely registered an increase in its mean score, surpassing the stipulated benchmark of >= 3.25 to achieve a mean of 3.26 and satisfying the Rating Variant criterion (*qi*) criterion of <15%.

In the context of the percentages assigning ratings of 3 or 4 on a 4-point Likert scale, a solitary competency, *Circular Impact Assessment* (*D2*), demonstrated a regression below the threshold level, with % f(3/4) recorded at 67%. Consequently, after the completion of two Delphi rounds, a total of 31 key competencies were ratified as having satisfied all evaluative criteria and thus were endorsed. On the contrary, 27 key competencies were adjudicated as not meeting the requisite standards and were therefore excluded from further consideration. These determinations are encapsulated in the *Final Result* section of Table 4. The study was brought to a conclusion at the end of Round 2, following the achievement of a consensus among the panel of experts.

Table 7

Analysis of the ratings in the two rounds of ratings given by the Panel of Experts

Code	Round	Ratings given by expert				($\bar{x}$)	% ƒ(3/4)	Rating Variant (qi) %
		f(1)	f(2)	f(3)	f(4)			
A3	Round 1	0	7	25	12	3.11	84	**23**
	Round 2	0	8	18	13	3.13	79	
A16	Round 1	1	9	25	9	2.95	77	**28**
	Round 2	2	6	19	12	3.05	79	
A21	Round 1	0	10	24	10	3.00	77	**28**
	Round 2	3	7	17	12	2.97	74	
B9	Round 1	2	6	21	15	3.11	82	**23**
	Round 2	1	7	15	16	3.18	79	
B10	Round 1	0	9	27	8	2.98	80	**18**
	Round 2	0	6	28	5	2.97	85	
C2	Round 1	2	9	26	7	2.86	75	**38**
	Round 2	2	5	20	12	3.08	82	
C7	Round 1	1	10	26	7	2.89	75	**13**
	Round 2	0	7	25	7	3.00	82	
D2	Round 1	0	9	29	6	2.93	80	**33**
	Round 2	0	13	20	6	2.82	67	
D3	Round 1	0	7	20	17	3.23	84	13
	Round 2	0	5	20	14	3.26	87	

Discussion

This study rigorously explores the essential design competencies required to effectively address the multifaceted challenges of sustainability in graphic design education. It underscores the pivotal role of foundational skills such as creativity, critical thinking, and effective communication, which are indispensable for both problem-solving and persuasive communication within the domain of graphic design (Thornhill-Miller et al., 2023). These competencies are highlighted as crucial for enabling designers to innovatively and empathetically tackle sustainability challenges, thereby promoting a shift from traditional, rigid design methodologies to more flexible, problem-oriented approaches. Importantly, the research advocates for a balanced educational framework that integrates solid design competencies with a robust understanding of sustainability principles. This is essential to prepare students not only to engage creatively but also to act effectively within the sustainability context. The study aligns with existing literature that emphasizes the necessity of a broad grasp of social, environmental, and commercial dynamics to successfully navigate the complexities of sustainable design (Swanson, 2020; Deniz, 2016).

The curriculum's emphasis is on cultivating a fundamental comprehension of key sustainability concepts such as the circular economy, eco-materials, and the broader impact of design choices, rather than a deep specialization in tools like circular logistics or detailed sustainability analysis. This approach reflects a strategic educational shift towards building versatile problem-solving skills over narrow technical proficiencies, which might be more relevant to specific, specialized roles within the field. This prioritization of generalist over specialist skills is corroborated by studies suggesting that while specialized knowledge can be crucial, the versatility of foundational skills often provides a stronger base for addressing diverse design problems (Fass et al., 2018).

Furthermore, the study indicates a notable preference for teamwork over leadership skills within the curriculum, possibly reflecting the collaborative nature of contemporary design practices and the overlapping competencies between leadership and critical thinking. This curriculum design ensures that graduates are equipped with a comprehensive skill set that is adaptable to a variety of design scenarios, even at the cost of sacrificing depth in certain specialized areas. It would be beneficial to evaluate the effectiveness of this revised curriculum in preparing graduates to confront real-world sustainability challenges in their professional practices. Such studies could further refine our understanding of the balance between foundational and specialized competencies in design education, particularly in the context of sustainable practices.

In conclusion, this study contributes to the ongoing discourse on design education by delineating a clear educational pathway that balances design competencies with sustainability principles, ensuring that future designers are well-prepared to contribute meaningfully to the global sustainability agenda.

Conclusions, Implications and Limitations

This study delved into the crucial competencies emphasized within graphic design education, particularly how these competencies align with the overarching needs of the design industry and contribute to addressing systemic sustainability challenges. The study identified high-consensus competencies such as creativity, critical thinking, visual and verbal communication, and prototyping. These are affirmed as aligning well with core design requirements and underscore the necessity of equipping students with robust tools for creative problem-solving and effective communication, fundamental across a spectrum of graphic design roles.

Further, the study delineated a specific set of core competencies: systems thinking, holistic thinking, understanding of materials and manufacturing processes, and user-centered design principles as critical for tackling systemic challenges. The deliberate exclusion of overly specialized skills underscores the importance of foundational knowledge across diverse design roles, suggesting that broad, versatile skill sets may be more beneficial than highly specialized competencies in the current educational landscape.

Theoretically, this study enriches the academic discourse by systematically compiling and organizing existing research on designer competencies related to sustainability. It elucidates critical competencies necessary for graphic design students to successfully navigate the challenges within identified domains, thereby contributing significantly to the literature.

Practically, the outlined competencies serve as a strategic guide for both educational institutions and industry. For educators, this scaffolding informs pedagogical strategies and curriculum development, aiming to cultivate designers well-versed in sustainability and adept in their craft. For the industry, this competency framework can guide talent acquisition, ensuring that new hires possess the requisite skills to thrive in dynamic design environments and contribute meaningfully to sustainability.

Despite its insights, this study acknowledges several limitations. The systematic review was confined to fourteen key papers, potentially limiting the breadth of competencies identified. The insights from 44 experts, while valuable, may not encompass the full spectrum of global design community perspectives. These constraints suggest the need for further research involving a broader array of literature and a more diverse and extensive panel of experts to enhance the robustness and applicability of the findings.

Additionally, the study did not explore specific pedagogical strategies that could be most effective in developing these competencies among graphic design students. Future research should investigate instructional designs and curriculum frameworks that effectively nurture these essential skills, aligning educational programs with both market demands and sustainability imperatives.

In sum, this study provides a foundational understanding of the competencies essential for graphic design students to contribute effectively to sustainability goals and excel in the modern job market. It lays the groundwork for future research to expand methodological approaches and pedagogical strategies, which is crucial for refining and advancing our understanding of how best to prepare designers for the challenges of sustainable development and professional practice.

Declaration of Interest

The authors declare no competing interest.

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Received: *March 14, 2024* Revised: *April 27, 2024* Accepted: *May24, 2024*

Cite as: Le Quyen, T. T., Liou, S., & Yang, C. H. (2024). Identifying and validating sustainable development goals-related key competencies in undergraduate graphic design education. *Problems of Education in the 21st Century*, *82*(3), 371–389. https://doi.org/10.33225/pec/24.82.371

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