RGC Ref. No.:
UGC/FDS24/H04/22
(please insert ref. above)

RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR

FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report
(for completed projects only)

Submission Deadlines:
1. *Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
2. *Completion report: within **12** months of the approved project completion date.*

Part A: The Project and Investigator(s)

1. Project Title

The Science of Design Thinking: Theories and Applications

(設計思維的科學: 理論及應用)

2. Investigator(s) and Academic Department(s) / Unit(s) Involved

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	Dr NG Sun-pui / Associate Head of Research	Division of Science, Engineering and Health Studies / PolyU-SPEED
Co-Investigator	Prof LO On-ting / Assistant Professor (Teaching)	Department of Psychology / Lingnan University
Co-Investigator	Dr HO Robbie Ming-hon / Research Assistant Professor	Department of Cultural and Creative Arts / The Education University of Hong Kong
Co-Investigator	Dr TSANG Wallace Wai-hung / Assistant Professor	Department of Social Work / Hong Kong Shue Yan University

Research Team	Name / Post	Unit / Department / Institution
Co-Investigator	Dr NG Sally Sau-yee / Senior Lecturer	Division of Science, Engineering and Health Studies / College of Professional and Continuing Education
Research Assistant	Miss KEUNG Sum-yuet	General Office / PolyU SPEED

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval *(must be quoted)*
Project Start Date	01/01/2023	N/A	N/A
Project Completion Date	30/06/2024	N/A	N/A
Duration *(in month)*	18	N/A	N/A
Deadline for Submission of Completion Report	30/06/2025	N/A	N/A

4.4 Please attach photo(s) of acknowledgement of RGC-funded facilities / equipment.

N/A

Part B: The Final Report

5 Project Objectives

5.1 Objectives as per original application

1. *The research team will conduct both quantitative and qualitative research studies to systematically investigate and explore the scientific nature of DT disposition and skills, with regard to its psychosocial antecedents (e.g., personality attributes, thinking styles, socioeconomic status, etc) and consequences (e.g., academic well-being, academic performance, entrepreneurship, etc). Quantitative data will be obtained through survey studies (with scientifically validated scales) whereas qualitative data will be obtained through focus group interviews from different stakeholders in colleges (Study 1 in this proposal). We will use both quantitative and qualitative data to build a model discerning the nature of DT scientifically. The qualitative data can be used to revalidate the model derived from the quantitative data.*

2. *Based on the findings of this proposal as well as insights from current models and theories, the research team will design a preliminary version of a DT training method. The efficacy of this training method will be tested in an experimental intervention study (Study 2 in this proposal). Ultimately, based on our research findings and progress, our objective is to develop a handy, preferably online, DT intervention method, which can be applied for mass online DT education efficiently.*

3. *The research team will make use of the knowledge and findings from this proposal and develop a new service learning subject at PolyU-SPEED, in which students will be exposed to DT training and such training can be applied to the services provided in the same subject*

4. *We propose to build a preliminary big data database regarding DT cases (Study 3 in this proposal). In this database, we will systematically document how design thinkers deal with the problems in various DT processes. The data will be stored in a NoSQL database in various formats including texts, videos, audios, weblinks, pictures and so on. Once the amount of data is big enough, big data analytics can be performed and valuable information can be found to facilitate scientific DT research and education in the future. In addition, data in this database can be used to revalidate the model derived from the quantitative data in Study 1 as well.*

5.2 Revised objectives

Date of approval from the RGC:	26/10/2022
Reasons for the change:	The authorized budget is substantially lower than the initially proposed budget.

1. *Study 1: The research team will conduct both quantitative and qualitative research studies to systematically investigate and explore the psychological correlates of design thinking disposition and design thinking skills. Quantitative data will be obtained through survey studies. Qualitative data will be obtained through interview studies. We will use both quantitative and qualitative data to build a model discerning the psychological attributes of design thinkers scientifically. The qualitative data can be used to revalidate the model derived from the quantitative data.*

2. *Study 2: We propose to build a preliminary big data database regarding design thinking cases. In this database, we will systematically document how design thinkers deal with the problems in various design thinking processes. The data will be stored in a NoSQL database in various formats including texts, videos, audios, weblinks, pictures and so on. Once the amount of data is big enough, big data analytics can be performed, and valuable information can be found to facilitate scientific design thinking research and education in the future. In addition, data in this database can be used to revalidate the model derived from the quantitative data in Study 1 as well.*

5.3 Realisation of the objectives
(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

Revised Objective 1: Achievement Status: Fully Achieved

The research team successfully accomplished the revised Objective 1 through comprehensive quantitative and qualitative research that systematically investigated the psychological correlates of design thinking disposition. This objective was realized through three major empirical studies that employed rigorous methodological approaches, combining survey-based quantitative analysis with innovative qualitative assessment of actual design thinking skills. We conducted extensive cross-sectional survey studies with substantial sample sizes, 904 participants and 588 participants in the two published papers respectively, representing diverse demographic backgrounds. The quantitative approach employed validated psychological instruments to measure key constructs including trait cognitive flexibility, empathy dimensions (cognitive and affective), visualization abilities, ideation behaviors, openness to experience, and design thinking disposition. Through advanced statistical analyses including parallel mediation analysis and fuzzy set Qualitative Comparative Analysis (fsQCA), we successfully built empirically supported models identifying the psychological attributes of design thinkers.

To complement our quantitative findings and assess actual design thinking skills in practice, we conducted an innovative qualitative interview study involving 52 college students. This study employed a custom-designed design thinking skills evaluation workshop comprising three phases: briefing, implementation, and evaluation. Participants were tasked with designing assistive devices for visually impaired seniors, allowing us to observe authentic design thinking processes in action. Through structured interviews and design process flowcharts, we assessed participants' performance across the five fundamental design thinking processes (empathize, define, ideate, prototype, and test). Expert evaluators scored participants' design thinking skills using mutually agreed-upon assessment rubrics, providing objective measures of actual design thinking capabilities. The combination of quantitative disposition measures and qualitative skills assessment enabled us to build a comprehensive model discerning the psychological attributes of design thinkers. The first paper published in Design Studies established that cognitive flexibility serves as a fundamental predictor of design thinking disposition, with this relationship mediated by cognitive empathy (perspective-taking). The second paper published in the Design Journal using fsQCA revealed that cognitive traits (cognitive flexibility, ideation, and visualization) collectively explain 48% of variance in design thinking disposition. The ongoing qualitative study provides crucial validation by examining how these psychological traits manifest in actual design thinking performance.

Our research provides the first empirical evidence for the critical role of executive functions in design thinking, specifically highlighting cognitive flexibility as explaining 29.3% of variance in design thinking disposition. We clarified the previously ambiguous role of empathy by demonstrating distinct contributions of cognitive versus affective empathy dimensions. The qualitative component adds practical validation by demonstrating how these psychological traits translate into observable design thinking behaviors and skills.

Revised Objective 2: Achievement Status: Fully Achieved

A preliminary database was built for storing and retrieving design thinking cases. This database is able to systematically document all the information regarding the five fundamental design thinking processes. To validate the functionality of the newly developed database, the data of qualitative interview study obtained by Objective 1 were input for testing and the interface is shown in Appendix 1. The data were stored in a NoSQL database using MongoDB as it accepts various data formats including texts, videos, audios, weblinks, pictures and so on.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
1. Study 1: The research team will conduct both quantitative and qualitative research studies to systematically investigate and explore the psychological correlates of design thinking disposition and design thinking skills. Quantitative data will be obtained through survey studies. Qualitative data will be obtained through interview studies. We will use both quantitative and qualitative data to build a model discerning the psychological attributes of design thinkers scientifically. The qualitative data can be used to revalidate the model derived from the quantitative data.	✓	100%

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
2. Study 2: We propose to build a preliminary big data database regarding design thinking cases. In this database, we will systematically document how design thinkers deal with the problems in various design thinking processes. The data will be stored in a NoSQL database in various formats including texts, videos, audios, weblinks, pictures and so on. Once the amount of data is big enough, big data analytics can be performed, and valuable information can be found to facilitate scientific design thinking research and education in the future. In addition, data in this database can be used to revalidate the model derived from the quantitative data in Study 1 as well.	✓	100%

6 Research Outcome

6.1 Major findings and research outcome

(Maximum 1 page; please make reference to Part C where necessary)

Major findings: This research project achieved significant theoretical advancement by providing the first comprehensive scientific foundation for design thinking through rigorous empirical investigation. Our findings fundamentally challenge existing assumptions about design thinking by establishing that cognitive traits, rather than empathic abilities alone, serve as the primary psychological drivers of design thinking disposition. Our research identified cognitive flexibility as the most critical psychological trait underlying design thinking disposition, explaining 29.3% of variance (refer to the paper published in the Design Journal). This represents the first empirical validation of executive functions' role in design thinking, addressing longstanding criticisms about the field's theoretical foundations. We also resolved the ambiguous role of empathy by demonstrating that cognitive empathy (perspective-taking) mediates the relationship between cognitive flexibility and design thinking disposition, while affective empathy (empathic concern) serves as an amplification factor rather than a fundamental requirement (refer to the paper published in the Design Studies). Through fsQCA analysis, we discovered that cognitive traits (cognitive flexibility, ideation, and visualization) collectively explain 48% of design thinking disposition variance, with specific trait combinations predicting both high and low design thinking performance (refer to the aper published in the Design Journal).

Methodological Innovations: Our integration of quantitative surveys (1,492 total participants) with qualitative skills assessment (52 participants) provides robust validation of psychological predictors through both dispositional measures and actual performance evaluation (i.e., mixed methods design). We also pioneered the application of fsQCA methodology to design thinking research, revealing complex trait interactions that traditional regression analysis cannot capture.

Database for Design Thinking Cases: Design thinkers' experiences are priceless assets that can facilitate the knowledge transfer process to design trainees. Nonetheless, the design thinking reasoning in design thinkers' minds would be lost it is not systematically documented, and this problem is a significant disadvantage for design thinking education in the future. The developed MongoDB database in the current project systematically stores all the information in various formats (e.g. texts, audios, videos, pictures, web links and so on) regarding the processes of solving problems using design thinking (Appendix 1). To manage the data efficiently and allow users to perform multiple tasks with ease, the database in this project is managed and accessed electronically through computers. The database is serving a function of knowledge exchange and open science practice.

6.2 Potential for further development of the research and the proposed course of action *(Maximum half a page)*

Longitudinal study: Our current cross-sectional and qualitative findings provide a robust foundation for extended longitudinal studies. Building on our published work, we have recently conducted a three-wave longitudinal investigation (data collection has been finished) examining the reciprocal relationship between design thinking disposition and entrepreneurial intention, currently under peer review (see Part C). This study employs cross-lagged panel modeling to establish temporal precedence and explore causal mechanisms, representing a significant methodological advancement from our initial cross-sectional approaches. Future research should continue tracking participants across extended time periods to establish how design thinking disposition develops through different life stages and training interventions. The reciprocal relationship we identified between design thinking and entrepreneurial intention, particularly the mediating role of cognitive flexibility, warrants deeper investigation through randomized controlled trials that manipulate these key variables.

Intervention study: The identification of cognitive flexibility as the primary driver across our studies provides clear direction for intervention development. We propose designing and testing targeted training programs that enhance cognitive flexibility, perspective-taking abilities, and ideation skills. These evidence-based interventions should be evaluated through rigorous experimental designs to determine their effectiveness in improving both design thinking disposition and entrepreneurial intention, particularly among younger adults where our longitudinal findings show stronger reciprocal relationships.

Neuropsychological study: The cognitive mechanisms we identified provide opportunities for neuroimaging validation using fMRI or EEG during actual design thinking tasks. Developing computer-based assessment tools that combine our validated psychological measures with interactive design thinking scenarios would enable scalable evaluation and training platforms, incorporating machine learning for personalized feedback.

7 Layman's Summary

(Describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

This research investigated what makes someone good at design thinking, a creative problem-solving approach used by companies like Apple and Google to develop innovative products and services. Design thinking involves understanding users' needs, brainstorming creative solutions, and testing ideas through prototypes.

We studied over 1,500 young adults to identify the key psychological traits that predict design thinking ability. Our findings revealed that cognitive flexibility, the mental ability to adapt thinking and switch between different approaches, is the most important factor. People who can mentally "change gears" and view problems from multiple angles are naturally better at design thinking. We also discovered that cognitive empathy (understanding others' perspectives) plays a crucial role, while emotional empathy (feeling others' emotions) is less important than previously thought.

These findings have practical implications for education and training. Rather than focusing solely on teaching empathy, educators should prioritize developing students' cognitive flexibility through exercises that challenge them to think adaptively and consider multiple solutions. This research provides the first scientific foundation for understanding design thinking, moving beyond anecdotal evidence to establish what actually makes someone an effective design thinker.

Part C: Research Output

8 Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project

(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				**Author(s)** *(denote the corresponding author with an asterisk*)*	**Title and Journal / Book** *(with the volume, pages and other necessary publishing details specified)*	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
Year of Publication	**Year of Acceptance** *(For paper accepted but not yet published)*	**Under Review**	**Under Preparation** *(optional)*						
2025	-	-	-	Sammi SY Keung, On-Ting Lo*, Sun-Pui Ng	Sammi S. Y. Keung, On-Ting Lo & Sun-Pui Ng (2025) Exploring trait factors associated with design thinking disposition in young adults: A fuzzy set qualitative comparative analysis (fsQCA), The Design Journal, 28:3, 627-651, DOI: 10.1080/14606925.2025.2452904	No	Yes (Appendix 2)	Yes	Yes

The Latest Status of Publications				**Author(s)** *(denote the corresponding author with an asterisk*)*	**Title and Journal / Book** *(with the volume, pages and other necessary publishing details specified)*	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
Year of Publication	**Year of Acceptance** *(For paper accepted but not yet published)*	**Under Review**	**Under Preparation** *(optional)*						
Expected 2025 June	✓	-	-	On-Ting Lo*. Sun-Pui Ng, Sally Ng, Veronica Lai, Sammi S. Y. Keung	Unraveling the Nature of Design Thinking Disposition: Contributions of Trait Cognitive Flexibility and Trait Empathy on Design Thinking Potential/Design Studies	No	Yes (Appendix 3)	Yes	Yes
-	-	✓	-	On-Ting Lo*	The reciprocal relationship between design thinking disposition and entrepreneurial intention: A cross-lagged panel model study/ Journal of Innovation and Entrepreneurship	No	Yes (Appendix 4)	Yes	No (still not published)

9 Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered
(Please attach a copy of each conference abstract)

Month / Year / Place	**Title**	**Conference Name**	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the Institutional Repository** *(Yes or No)*
N/A						

10 Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning
(Please elaborate)

The design thinking concepts and research experience were introduced in the courses of SEHH2248 Engineering Design Fundamentals, SEHS4618 Aircraft Systems as well as SEHS4611 Final Year Capstone Project.

11 Student(s) Trained
(Please attach a copy of the title page of the thesis)

Name	**Degree Registered for**	**Date of Registration**	**Date of Thesis Submission / Graduation**
	Bachelor of Engineering (Hon) in Mechanical Engineering, PolyU SPEED	1 September 2022	5 May 2024 (As Final Year Projects)

12 **Other Impact**
(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

NA

13 **Statistics on Research Outputs**

	Peer-reviewed Journal Publications	**Conference Papers**	**Scholarly Books, Monographs and Chapters**	**Patents Awarded**	**Other Research Outputs (please specify)**	
No. of outputs arising directly from this research project	2 (1: Published 2: Accepted to be published)	-	-	-	Type	No.
					-	

14 Public Access Of Completion Report

(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	**Reasons**
N/A	