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A Phenomenographic Study of Chinese Junior Secondary School Students' Conceptions of Technology

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Abstract

Fostering students' comprehensive conceptions of technology (COT) is a critical goal of technology education. While international research on COT is extensive, studies focusing on mainland China—a context with a unique technological history—remain scarce. This phenomenographic study investigates the COT of 61 Chinese junior secondary students (aged 13-15) through semi-structured interviews and photo-elicitation. The findings reveal that students conceptualize technology across five dimensions: attributes, generation, operation and use, mastery, and functions. Compared to their primary school counterparts, junior secondary students exhibit both more nuanced rational views (e.g., technology as activity, symbol of civilization) and persistent partial understandings (e.g., fragmented views of experiential vs. scientific technology). The study highlights the influence of sociocultural context and weak school-based COT education on student understanding. The findings offer empirical insights for technology educators and policymakers in China and similar cultural settings, suggesting the need for curricula that explicitly integrate the multidimensional nature of technology.

Key Words: Conceptions of Technology, Junior Secondary Students, Mainland China, Phenomenography, Technology Education

1 INTRODUCTION

Cultivating students' appropriate conceptions of technology (COT) is a key goal in technology education worldwide, influencing their critical thinking, career choices, and engagement with technology (Eliasson et al., 2022). While studies have explored COT in various countries, limited research focuses on mainland China, a context with a unique technological history and curriculum development (Su & Ding, 2023). This study, part of a series examining Chinese students' COT, investigates junior secondary students (aged 13–15) and compares results with earlier findings from primary students to chart developmental trajectories. The research questions are:

(i) What are mainland China junior secondary students' COT?
(ii) How do COT evolve from primary to junior secondary school?

2 LITERATURE REVIEW

2.1 Defining Technology

Defining technology is challenging due to its multifaceted nature. A comprehensive understanding can be synthesized from philosophical frameworks. Mitcham (1994) conceptualized technology as artifacts, processes/activities, knowledge, and volition. De Vries (1996) further distinguished between experience-based technologies (rooted in empirical craft) and scientific technologies (macrotechnologies and microtechnologies derived from scientific principles). Additionally, technology is recognized as a double-edged sword with societal and ethical implications (De Vries, 2005). These nine elements (e.g., technology as artificial objects, as processes, as knowledge, as volition, as situational, as a system, as culturally shaped, its interdependence with science, and its dual nature) form the theoretical reference for understanding students' COT.

2.2 Empirical Studies on Secondary Students' COT

International research consistently shows secondary students hold limited and often narrow COT, frequently associating technology only with modern, electronic artifacts (Bame et al., 1993; DiGironimo, 2011). More recent studies using open-ended approaches reveal more nuanced, context-dependent understandings. For instance, Rücker and Pinkwart (2018) found German students categorize technology into types like high-tech, home, and 'real' technologies, while Molina-Vásquez (2021) identified Colombian students' conceptions linking technology to society, culture, and systems. However, a significant gap remains concerning Chinese students, whose technological conceptions are likely shaped by their distinct cultural and educational context.

2.3 Historical and Cultural Context of Technology in China

Chinese perspectives on technology have been deeply influenced by its history. Confucianism and Taoism traditionally devalued experiential technology, dismissing it as "diabolic tricks" (Du, 2003). Following military defeats in the 19th century, China was compelled to import Western scientific technology, leading to a reactive veneration of "keji" (science and technology), often conflating the two (Wu, 2016). This historical trajectory—from devaluation to a fragmented coexistence of experiential and scientific technology—forms the crucial socio-cultural background for students' COT.

2.4 Technology Education in Chinese Junior Secondary Schools

From 2001 to 2022, technology education for junior secondary students primarily relied on Labor and Technical Education, which lacked unified national standards. Its implementation was characterized by marginalization, insufficient instructional time, and a focus on skills rather than explicit COT education (Ding, 2009). Crucially, the curriculum did not systematically bridge the gap between traditional experiential technology and modern scientific technology. Although new standards were enacted in 2022, the students in this study were educated under the previous system, making this context essential for understanding their COT.

3 METHODOLOGY AND RESEARCH METHODS

3.1 Phenomenography and Theoretical Framing

This study adopts phenomenography, which explores the qualitatively different ways people experience a phenomenon (Marton, 1986). Its focus on the "second-order perspective"—how something is conceived—aligns with our aim to capture authentic student views without imposing a predefined framework. This stance is informed by the literature: the multifaceted nature of technology and the unique Chinese cultural context necessitate understanding COT as situated and varied. The study seeks to describe the structure of variation in how technology is conceived by this specific group.

3.2 Participants

Purposive sampling selected 61 students (30 male, 31 female) from rural, urban-rural, and urban schools in Hebei Province (20 rural, 20 urban-rural, 21 urban; 20 Grade 8, 41 Grade 9) to ensure regional and age diversity.

Table 1

The specific information of the participants

N = 61	Group			Total
	Rural	Urban-rural	Urban	
Boys				
Grade				
8th	8	2	0	10
9th	2	8	10	20
Total	10	10	10	30
Girls				
Grade				
8th	8	2	0	10
9th	2	8	11	21
Total	10	10	11	31
Total	20	20	21	61

3.3 Data Collection

Semi-structured interviews centered on "What is technology?" supplemented by 22 photo-eliciting images (representing Mitcham's four dimensions). Photo-elicitation is a well-established technique to prompt deeper reflection (Harper, 2002). Interviews (25-35 minutes) included photo selection and open discussion, with ethical safeguards (informed consent, confidentiality).

3.4 Data Analysis

Analysis followed the iterative phenomenographic approach (Åkerlind, 2005; Sjöström & Dahlgren, 2002). Meaning units were identified, grouped into categories of description, and structured into a hierarchical, non-exclusive "outcome space." Two researchers independently analyzed and cross-validated findings to ensure reliability.

4 RESULTS (THE OUTCOME SPACE OF JUNIOR SECONDARY STUDENTS' COT)

In phenomenographic research, the hierarchical nature of the outcome space suggests that conceptions may coexist at different levels and are context-sensitive. Specifically, individuals may possess multiple, non-exclusive COT that exist simultaneously at different levels (Rücker & Pinkwart, 2018). This study reveals that mainland China junior secondary school students define technology from five dimensions: the attributes of technology, the production of technology, the operation and use of technology, the functions of technology, and the mastery of technology. The five first-level categories of description encompass several subordinate and even tertiary ones, collectively forming each student's unique COT. Figure 1 shows the junior secondary school students' COT in mainland China.

4.1 The attributes of technology

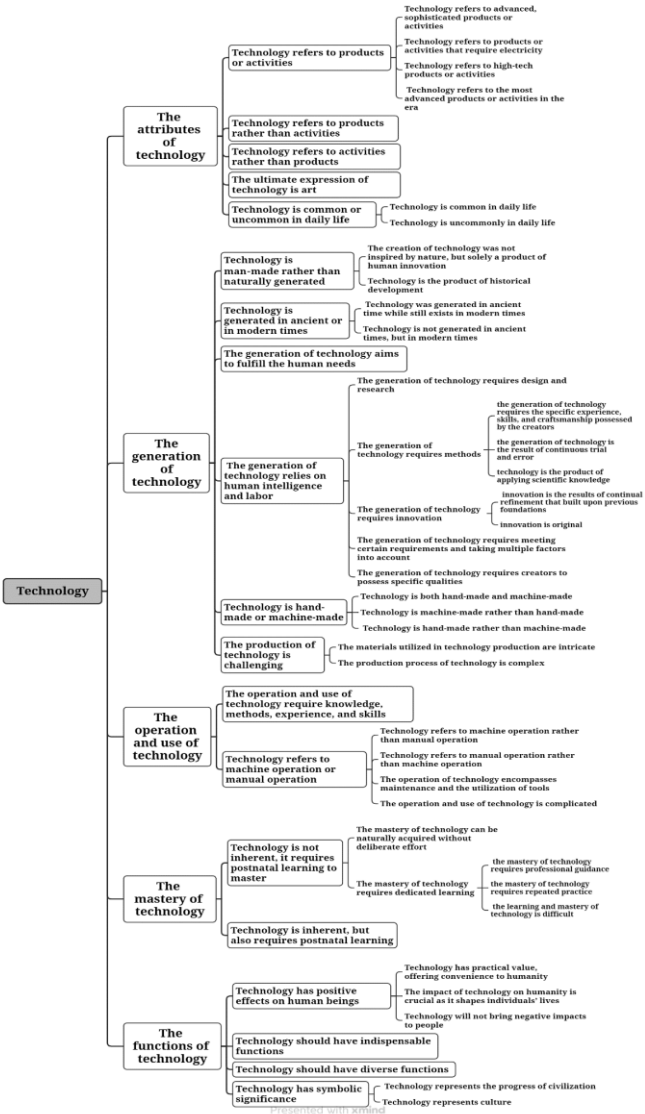
Students define technology from the dimension of the attributes of technology, which includes the following 5 secondary indicators:

4.1.1 Technology refers to products or activities

This category of description regards technology as products or activities, which further includes the following four sub-indicators: twenty-two interviewees (36%) believed that technology refers to advanced, sophisticated products or activities, e.g., N-17-M stated: 'Using a washboard is not technology; using a washing machine is, because it is more advanced.'; twenty students (33%) believed that technology refers to products or activities that require electricity, e.g., C-6-M stated: 'An electric toothbrush is technology; a regular one is not, because it relies on electricity.'; Twenty-one interviewees (34%) considered that technology refers to high-tech products or activities, e.g., C-18-M stated: 'A glass cup is not technology; technology involves high-tech things like computers and phones.'; Twelve students (20%) held the view that technology refers to the most advanced products or activities in the era, e.g., C-7-M stated: 'An electric toothbrush is technology; a regular one is not. But a regular toothbrush was technology when first invented.'

Figure 1

Junior secondary school students' conception of technology in mainland China



4.1.2 Technology refers to products rather than activities

Seven junior secondary students (11%) believed that technology refers to products, while the process of making or using the products is not. This perspective on technology is one-sided, e.g., X-12-F stated: 'Phones and computers are technology, but using them is not. Technology is the outcome.'.

4.1.3 Technology refers to activities rather than products

Nineteen middle school students (31%) considered that technology is dynamic rather than static. Specifically, they viewed technology as the dynamic process of creating products or operating them, where the products themselves are not seen as technology but as the results of technology, e.g., C-4-F stated: 'A washboard itself is just an object; when not used, it is not technology. When used, it becomes a tool.'

4.1.4 The ultimate expression of technology is art

Five students (8%) considered that there is a connection between technology and art, with art being the ultimate expression of technology, e.g., C-8-M stated: 'When pottery reaches its highest level, the beauty in it turns into art.'

4.1.5 Technology is common or uncommon in daily life

Thirty students (49%) defined technology based on its frequency of occurrence in daily life. This indicator comprises the following two sub-indicators: technology is common in daily life, considering anything uncommon as not technology, e.g., X-18-M stated: 'Making pottery is not technology; it is not commonly seen. Technology is common in daily life.'; twenty-three students (38%) held the belief that technology is uncommonly in daily life and is something that ordinary people cannot or rarely engage with directly. Products or activities that are commonly observed in daily life are viewed as ordinary and not classified as technology, e.g., N-8-M stated: 'Satellites are technology because they are uncommon. Ancient wine cups are not; they were widely used.'

4.2 The generation of technology

Students defined technology from the perspective of its generation. Data analysis reveals that this dimension encompasses the following six sub-indicators:

4.2.1 Technology is man-made rather than naturally generated

Students perceived technology as a human invention rather than a natural phenomenon. This category of description comprises two tertiary indicators: two students (3%) believed that the creation of technology was not inspired by nature, but solely a product of human innovation, e.g., N-6-F stated: 'Ancient wine cups are not technology; they have natural prototypes. Technology is something newly created by humans.'; eight respondents (13%) thought that technology is the

product of historical development, e.g., N-9-F stated: ‘Satellites are technology; they are an inevitable outcome of social progress over time.’

4.2.2 Technology is generated in ancient or in modern times

Students conceptualized technology based on the time of its invention, encompassing two sub-dimensions: Ten students (16%) considered that technology was generated in ancient time while still existing in modern times, e.g., C-9-F stated: ‘Making pottery is technology; it has been passed down from ancient times to the present.’; seven students (11%) argued that technology is not generated in ancient times, but in modern times, e.g., C-7-M stated: ‘Technology is a product of modern times. Ancient wine cups are not technology; they are just vessels.’

4.2.3 The generation of technology aims to fulfill human needs

Fourteen students (23%) defined technology from the perspective of its purpose, viewing its generation as a result of human needs. This viewpoint highlights the close relationship between technology and humanity, e.g., N-7-M stated: ‘A T-shirt is technology; its design and production should consider different needs of people.’

4.2.4 The generation of technology relies on human intelligence and labor

The students believed that human intelligence and labor are essential factors for the development of technology. This category of description encompasses five sub-dimensions: thirteen interviewees (21%) deemed the generation of technology requires design and research, e.g., X-17-M stated: ‘A glass cup is not technology; it does not require complex design. Technology requires complex design.’; thirty-eight students (62%) believed the generation of technology requires methods. Within this, 21 students (34%) held the view that the generation of technology requires the specific experience, skills, and craftsmanship possessed by the creators, e.g., N-7-M stated: ‘Farming is technology. I tried but failed; successful farming requires experience and skill.’; 17 students (28%) thought that technology is the product of applying scientific knowledge, e.g., C-3-M stated: ‘Satellites are the result of scientific research. T-shirts are not really related to technology.’

4.2.5 The generation of technology requires innovation.

This perspective posits that innovation is a prerequisite for the generation of technology. Innovation refers to the creation of something new that did not exist before. Regarding the modes of innovation, five individuals (9%) believed that innovation is the results of continual refinement that builds upon previous foundations, e.g., N-19-M stated: ‘Laptops are technology; they are created by enhancing electronic chips based on phones.’; two individuals (3%) considered that innovation is original, e.g., C-15-F stated: ‘Bronze cups are technology because they are original creations representing ancient innovation.’ Eight students (13%) discussed that the generation of technology requires meeting certain requirements and taking multiple factors into account; nine students (15%) mentioned that the generation of technology requires creators to possess specific qualities. 35% students argued that technology is hand-made or machine-made.

4.2.6 The production of technology is challenging.

This category of description defines technology based on the level of difficulty in its production, which encompasses two sub-indicators: nine middle school students (15%) stated that the materials utilized in technology production are intricate; thirty-six students (59%) contended that the production process of technology is complex, e.g., X-17-M stated: 'A highway is not technology; it is simple. Building a bridge is technology; it involves complex measurements.'

4.3 The operation and use of technology

The dimension defines technology from the standpoint of operation and utilization, consisting of four sub-indicators.

4.3.1 The operation and use of technology require knowledge, methods, experience, and skills

45 students (74%) argued that technology operation and use require knowledge, methods, experience, and skills, e.g., X-6-F stated: 'Repairing cables is technology; it requires circuit knowledge and high skill.'

4.3.2 Technology refers to machine operation or manual operation

Students defined technology from the perspective of the way in which it is operated and used. This category of description contains two sub-indicators: fourteen students (23%) believed that technology refers to machine operation rather than manual operation, e.g., N-1-M stated: 'An electric toothbrush is technology; a regular one is not because it is manually operated.'; one student (2%) regarded technology refers to manual operation rather than machine operation, e.g., C-8-M stated: 'Using a washboard is technology; it requires practice. Using a washing machine is not; just press a button.'

4.3.3 The operation of technology encompasses maintenance and the utilization of tools

16 students (26%) considered that technological operations involve maintenance and tool use, e.g., C-12-M stated: 'Fixing cars is technology; it requires tools. Things need maintenance after being made.'

4.3.4 The operation and use of technology is complicated

Twenty-eight students defined technology based on the level of difficulty in its operation and usage. They believed that the operation and usage of technology are often challenging and complex, and if the operation is easy, then it is not technology, e.g., C-8-M stated: 'Using phones for basic things is not technology unless it requires advanced skills, like hacking.'

4.4 The mastery of technology

This dimension defines technology from the perspective of its mastery, consisting of two sub-indicators: technology is not inherent, it requires postnatal learning to master; technology is inherent, but also requires postnatal learning.

4.5 The functions of technology

The dimension defines technology from its functional role, and it includes four sub-indicators.

4.5.1 Technology has positive effects on human beings

This description category asserts that technology has a positive influence on humanity. In particular, it includes three tertiary indicators: 37 students (61%) believed that technology has practical value, offering convenience to humanity, e.g., X-18-M stated: 'Satellites help people go online. Phones are technology; they provide convenience and save time.'; nine students (15%) believed that the impact of technology on humanity is crucial as it shapes individuals' lives, e.g., C-4-F stated: 'A toolbox is technology. Tools are crucial in manufacturing and daily life.'; 6 students (10%) considered that technology will not bring negative impacts to people, e.g., N-13-M stated: 'Technology should bring benefits. Electric toothbrushes break easily; phones cause addiction. So they are not technology.'

4.5.2 Technology should have indispensable functions

Six students (10%) thought that technology is unique and cannot be replaced by other products or activities. If a product or activity can be replaced by something else, then it is not technology, e.g., N-17-M stated: 'Computers are technology because they are unique and cannot be replaced.'

4.5.3 Technology should have diverse functions

Eighteen students (30%) argued that technology should have various functions. If it only serves a single function, it cannot be considered technology, e.g., C-5-M stated: 'A glass cup is not technology; it has a single function. Technology should have multiple functions.'

4.5.4 Technology has symbolic significance

This category of description defines technology from its symbolic significance, which is a unique COT among Chinese junior secondary school students. It specifically includes two secondary indicators: 5 students (8%) considered that technology represents the progress of civilization, e.g., C-16-M stated: 'Satellites represent social progress. Pottery-making helped civilization move forward.'; eleven students (18%) argued that technology represents culture, e.g., C-8-M stated: 'Ancient wine cups are symbols of culture. Washboards represent the wisdom of our ancestors.'

5 LIMITATIONS OF THE RESEARCH

This study has a limited sample (n=61) from three schools in one Chinese province, which may affect generalizability. Future research could expand the sample to include a wider range of regions and school types. The study also did not explore gender differences, suggesting a direction for future analysis. Furthermore, as a cross-sectional study, a longitudinal design would be valuable to better understand the developmental trajectories of COT over time.

6 DISCUSSION

This study reveals that Chinese junior secondary students possess both rational and partial COT, indicating an incomplete understanding of technology. Compared to Chinese primary students (Su & Ding, 2023), their views show developmental progression.

6.1 Development of More Rational and Nuanced COT

Junior secondary students exhibit more multidimensional rational views. Unlike primary students who predominantly view technology as products, they define technology as activities, including design, tool use, and maintenance (Lachapelle & Cunningham, 2019; Xu et al., 2021). Their understanding of technology as a human creation to meet needs is clearer, encompassing volition, innovation, and necessary creator traits (Mitcham, 1994; DiGironimo, 2011). They more precisely define technology as knowledge acquired through specialized learning. Uniquely, they develop symbolic interpretations, viewing technology as representing civilization (Jiang, 2009) and culture (Molina-Vásquez, 2021), and some propose "the ultimate expression of technology is art"—a view not found in prior empirical studies.

6.2 Persistence and Emergence of Partial COT

Several partial COT persist from primary school. A key issue is the fragmented view of technology types: some students recognize only scientific/modern technology (e.g., requiring electricity), while others recognize only experiential/traditional technology (e.g., handcraft) (Ankiewicz, 2016). Many hold a unilateral view of the science-technology relationship, seeing technology merely as applied science. Other persistent partial COT include defining technology only as products and denying negative impacts. New partial conceptions emerge, notably a belief in "technological autonomy"—that technology develops independently of human will (Burns, 1992).

6.3 A Comparison of Dimensional Structures Across Educational Stages

A deeper comparison with primary school findings (Su & Ding, 2023) reveals not just a refinement in content, but a shift in the structural relationship between the five COT dimensions. While both groups conceptualize technology across the same five dimensions, junior secondary students exhibit a more integrated structure. For example, their understanding of "generation" is more consistently linked to "attributes" of complexity and to "functions" of fulfilling needs, forming a more cohesive narrative of technology as a purposeful process. This suggests that a

broader, more specialized junior secondary curriculum may facilitate the synthesis of disparate ideas.

6.4 Influencing Factors and the Role of Education

Students' COT are shaped by life experiences as "digital natives" (Prensky, 2004). However, weak school-based COT education appears to be a primary reason for incomplete understanding. In China, technology-related curricula have historically focused on skills without providing systematic, explicit COT education to foster integrated understanding across experiential and scientific technology domains. The variety of courses in junior secondary school (e.g., sciences, history) likely contributes to their more nuanced views compared to primary students (Stables, 1994).

6.5 Impact of Cultural-Historical Context

Crucially, students' COT are embedded in China's unique context. The focus on technology as activity is a unique Chinese finding, likely influenced by the historical emphasis on craftsmanship. The fragmented understanding of technology types and the confused science-technology relationship may stem from China's history of passively importing Western scientific technology, which coexisted separately with its rich tradition of experiential technology. Looking ahead, future research could use the baseline COT identified here to assess the effectiveness of explicit COT instruction and employ established international instruments (e.g., PATT) for richer comparative analysis.

7 CONCLUSION

This phenomenographic study investigated the COT among Chinese junior secondary students. The results show that they have not yet formed comprehensive and rational conceptions of technology. Similar to elementary students, they define technology across five dimensions but with both more rational and partial views. Unique Chinese conceptions include "technology refers to activities," "technology represents culture," and "the ultimate expression of technology is art." Simultaneously, they exhibit a fragmented comprehension of scientific and experiential technology, alongside a confused understanding of the science-technology relationship.

The formation of these COT is influenced by multiple factors, with weak school-based COT education being a possible main reason for incomplete understanding. The findings underscore the need for curriculum development that moves beyond a skills-based approach. A more effective curriculum would explicitly teach the multidimensional nature of technology—as process, knowledge, and volition—and deliberately integrate its experiential and scientific dimensions. By providing students with a coherent framework to connect their fragmented experiences, such an approach could help them develop a more unified and accurate understanding of technology. This study provides empirical evidence for technology educators, curriculum policymakers, and teachers to enhance technology education in China and similar cultural settings.

8 AI DISCLOSURE

Artificial Intelligence (AI) technologies were used solely to enhance clarity and structure of the written text. All scholarly contributions, theoretical perspectives, and analyses were produced by the authors.

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10 APPENDIX

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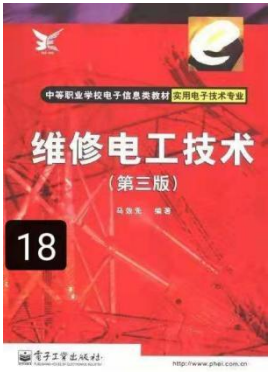
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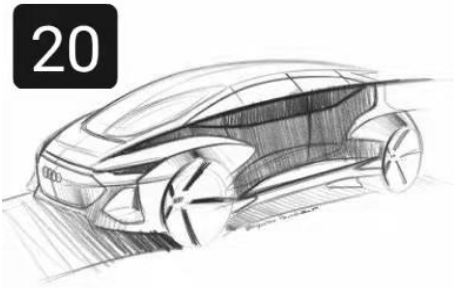
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