ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #37619

How (Inter)national Engineering Faculty Members Perceive and Teach Creativity: A Cultural Perspective

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Introduction

As a mental capability critical to innovation [1], creativity leads to improvements in our society by advancing our technology and productivity [2]. Moreover, as technology and society advance, more complex problems emerge [3] that require more creativity to solve. Engineers who must solve these problems, and the engineering educators who train engineers, widely agree that creativity is important in almost every aspect of engineering [4].

Therefore, it is essential that engineering faculty members seeking to prepare their students for an increasingly complex, innovation-driven workforce should demonstrate not only an *understanding* of and a *desire* for creative thinking in their classrooms, but also *competency* in teaching creativity, including creative thinking and creative practices. However, to help cultivate such competency, it is first important to understand how faculty members' growth environments and cultural backgrounds inform their understanding of creativity, including how such understanding affects their choices of teaching methods or strategies to foster students' creativity.

In this work, we used interviews with engineering faculty to explore (1) the impact of the cultural backgrounds on early-career engineering faculty members' perceptions and understanding of creativity and (2) the selection of creativity-fostering methods in instruction. The use of "(inter)national" within the title of this essay is intended to represent two ways of comparing and contrasting: (1) faculty that were born in the same continent or similar culture, which is expressed through emphasizing the prefix *inter-* within parentheses, as well as (2) faculty living and working in a country different from their country (or culture) of upbringing, expressed through the term international.

Our research questions include:

- How do early-career engineering faculty members' perceptions of creativity vary across their cultural backgrounds?
- How do early-career engineering faculty members' creativity teaching methods vary across their cultural backgrounds?

Literature Review Creativity Definition in the Western World

Western researchers have defined creativity in many different ways. Some researchers consider creativity to be an *ability* to create new or novel things from what people already have [5]. Some researchers believe that creativity should also be practical or useful to society [6]. In addition to viewing creativity as a kind of *capability* or mental attribute or as an *end result*, other researchers, such as Torrance [7], posit that creativity is a *process* consisting of exploration, verification, and interpretation.

In addition to these definitions, Csikszentmihalyi [8] explored a different approach based on assessing the impact of work on a discipline, daily life, or the entire world or society, dividing creativity (or creative acts, practices, and thinking) into little-c and Big-C types of

creativity. This classification of creativity was complemented by Kaufman and Beghetto [9] raising the concepts of mini-c and Pro-c. While little-c means a small innovation in daily life and Big-C reflects a major one that may significantly revolutionize society or the world, mini-c refers to "novel and personally meaningful interpretation of experiences, actions, and events," and Pro-c indicates a relatively impactful contribution to a professional field but not yet to the level of Big-C [10, p. 3]. According to these definitions, mini-c is smaller than little-c, which Pro-c outweighs, and finally, Big-C stands for the top level of creativity.

Creativity Definition in Asia

In East Asian cultures, creativity means evolutionary changes made to society in a mild and progressive process, rather than a sudden and radical way to change the current social system [11]. This definition is similar to Csikszentmihalyi's [8] Big-C concept but suggests that a creative change occurs in a slow way.

Many East Asian societies define creativity as a cognitive capability to gain information, construct knowledge, and apply solutions to problems in new or novel ways [12]. Some of these societies, for example, mainland China, emphasize creativity particularly in the fields of science and technology, while other societies, such as Hong Kong, Taiwan, and Singapore, emphasize creativity in various areas, including science, technology, arts, and humanities, *and* at multiple levels, including personal, school, industrial, societal, and cultural levels [12].

Creativity in Japan and South Korea follows an imitation-to-innovation model: A creative idea starts from imitation, then is studied, consumed, or filtered; many imitated ideas are collected and assimilated, and finally, are applied back to the original problem to improve people's life or change the development of society [13]. Middle school teachers in South Korea perceive creativity as novelty, uniqueness, good memorization, divergent thinking, free learning environment, resource-integrating, problem-solving, social capability, and mutual respect, which are partially aligned with western definitions of creativity [14].

In China, previous researchers have found many overlaps of Chinese definitions of creativity, such as being smart, outstanding, innovative, imaginative, flexible, willing to try, etc., with western definitions [15], [16]. However, unlike how some westerners define creativity as being nonconforming, tradition-rejecting, or authority-challenging [17], common Chinese definitions of creativity view creativity as a mental ability to discover the principles and laws of nature and to figure out how to respond creatively to these principles/laws [18]. Furthermore, Chinese definitions of creativity differ from western definitions in three collectivistic aspects: contributing to society, benefitting the general public, and being widely acknowledged [15]. In addition, being artistic and humorous [19], [20] are generally not deemed manifestations of creativity by Chinese definitions [15], [16].

South Asia and the Middle East areas share many commonalities in perceptions of creativity with western perceptions, but, as before, there are some differences. Researchers studied Indian students' perceptions of creativity and summarized four major categories of their understanding: Sociability and Social Responsibility, Leadership, Unconventional Personality Orientation, and Task Persistence [21]. These categories indicate some

discrepancies from western perceptions of creativity, which focused on the cognitive, process, or pragmatic attributes of creativity. Researchers found more similarities between Turkish and western perceptions of creativity; differences exist but are very small [22].

Cultural Factors Impacting Creativity

Few researchers have studied what and how cultural factors might impact creativity, particularly how it is perceived and taught within an engineering context. From a broad context, Hofstede [23]–[25] once proposed six dimensions that may affect people's creativity performance, which are: *collectivism-individualism*, *power distance*, *uncertainty avoidance*, *masculinity-femininity*, *long-term versus short-term normative orientation*, and *indulgencerestraint*. In Hofstede's definitions, *collectivism-individualism* describes the extent to which people value group wisdom compared to individual ideas; *power distance* describes the extent to which subordinates accept the unequal power distribution in an organization or a society; *uncertainty avoidance* describes the extent to which members of an organization or a society feel comfortable or uncomfortable in uncertain circumstances; *masculinity-femininity* describes the extent to which people respect men's values versus women's values; *long-term versus short-term normative orientation* describes the extent to which a long-term or shortterm plan or schedule may impact creativity within an organization or a society; and finally, *indulgence-restraint*, similar to the concept of *naïve dialect thinking* mentioned by Paletz and Peng [26], describes the extent to which an organization or a society is tolerant of different voices, ideas, or ways of thinking.

Other than Hofstede's six dimensions, other models' or cultural factors' impact on creativity have been proposed. "*face*" in East Asian culture might be one factor. Previous researchers found that people who worry about losing face in front of others might be less creative in generating ideas or solutions than those who do not care as much about face [27]. *Authority relations*, meaning the relationships between the superior and the subordinate, such as parent-child relationships, teacher/advisor-student relationships, and employer-employee relationships, may also impact the creativity that could be triggered within the relationship [28]. *Cultural tightness*, which means to what extent individuals in a society are required to obey rules or norms, was found negatively correlated with the creativity performance of that society [29].

Creativity and Engineering

Creativity is essential to engineering [30]. Creativity is more like a mental attribute to generate new and helpful ideas, and engineering is a field in which to manifest the level of creativity and make creative ideas concrete [31]. In higher education, however, fostering creativity in engineering has been underemphasized [31]. Using the Ten Maxims of Creativity in Education, an instrument to evaluate students' perceptions of how creativity is encouraged in their learning, researchers [32] found that creativity fostering methods are severely missing from students' perceptions.

Previous researchers and educators have explored various methods to foster creativity. For instance, brainstorming is a broadly-used method [33] across many disciplines. Creative writing could be used in various engineering fields [34]. Mind mapping is an excellent way to

organize students' thinking and ideas [35]. Activities that allow students to explore in a learning environment (e.g., game-based learning or learning in a virtual reality environment) develop students' creativity [36]. Methods borrowed from other disciplines could also promote students' creativity, for example, methods from theatre education [37]. Lastly, cultivating teachers' or instructors' creativity (e.g., [38]) to apply more creative teaching methods in classes is equally important as directly fostering students' creativity.

Higher Education in Asia and the U.S.

The fast economic growth in East Asia through the past decades has sustained the development of higher education in this region [39]. With sufficient funding support, higher education institutions in East and Southeast Asian countries or regions strove to become world-class institutions and adopted many strategies to reach that goal [40]. These strategies included focusing on global rankings, establishing university leagues, and paying attention to research performance (e.g., number of publications, journal indices, or counts of citation) [40]. Some regions such as China mainland, Hong Kong, and Taiwan encouraged private sectors to engage in higher education in order to enhance the global competitiveness of their higher education [41].

As for the education for students, most East and Southeast Asian countries or regions, under the guidance of the Confucian educational philosophy, use the "one chance" university matriculation exam to determine high school students' admission to a university or a vocational college [42, p. 594]. Successfully being accepted to a high-prestige university is believed to bring students glory and better career opportunities in the future [43]. Also, affected by the Confucian thoughts, these countries and regions have widely adopted traditional, teacher-centered learning modes where the teacher's authority is ingrained into students' mindsets [44]. Such a rigid, hierarchical teacher-student relationship may inhibit creativity in higher education classrooms [45]. However, active or student-centered learning methods are now being promoted, and some universities in East or Southeast Asia have achieved positive learning outcomes through adopting these new ways of learning (e.g., [46]). In addition, previous researchers have called for the promotion of creativity in Asian education [47], from both the teacher education side [48] and the student education side [18]. Other researchers have suggested that appropriate guidance should be provided and followed when we try to transfer educational practices from one education system to another due to the existence of cultural differences [49], which, on the other hand, posed obstacles to Asian countries' education reforms that were conducted smoothly in western countries [50].

South Asian countries had various enrollment ratios in higher education but overall at a low level because many countries in this region failed to see the benefits of developing higher education [51]. Wealth inequality was one of the primary reasons for the situation [52]. As the educational level increases, people in this region need more money to support themselves or educate their children [53]. The good news is that the overall higher education enrollment in South Asia has kept expanding in recent years; nonetheless, the quality, access, equity, and funding are still major issues [54]. The same issue also impacted higher education in Middle East countries; and because of the high dropout ratio in elementary, middle, and high schools, the higher education enrollment ratios in these countries were not high either [55]. A

generally low family socioeconomic status and the decreased funding level in higher education are major causes of low enrollment [56]. Reform in higher education in the Middle East is called for by researchers and educators [57].

Methodology Participants

Our participants were ten engineering faculty members from a Midwest R1 university in the United States. They all shared a background or expertise in the field of engineering. Nine were early-career faculty (with less than five years of teaching experience in higher education), while one had five to ten years of teaching experience in higher education. Eight of the faculty were tenure-track faculty, with one being recently tenured, and two were nontenure-track teaching faculty. Two of the faculty identified as women, while the remaining eight identified as men. Five were born and reared in Asian countries (two from China, one from India, one from Sri Lanka, and one from Turkey), while the other five were born and reared in North America (NA, all from the United States). Table 1 summarizes participants' genders and continents of birth and growth. Their specific countries of birth and growth were not displayed to maintain their anonymity.

Data Collection

Data collection occurred in Fall 2019 and 2020 academic terms, with, each year, five faculty members interviewed. Each year, two phases of individual in-depth interviews were conducted (see Fig. 1). In Phase One, the interviews explored the faculty members' teaching philosophies, including why they chose to teach, how they learned to teach, and what teaching methods they used in classes. In Phase Two, the interviews focused on their perceptions of creativity and how and when would be the best fit to integrate creativity into classes. Each interview lasted between 40 and 60 minutes. Each interview was audio recorded for data analysis purposes, with participants' consent acquired (IRB approval number 2013076).

Data Analysis

The interview recordings were transcribed into text using an online tool [58] and manually checked to balance the efficiency and the accuracy. A thematic analysis of the transcribed content was then conducted using NVivo New Release [59]. We followed a sixstep thematic analysis process proposed by Braun and Clarke [60] to ensure validity and reliability. The transcription was divided by interview questions. Under each question, excerpts (e.g., phrases or sentences) from the transcription were compared, and different codes were assigned to relevant content. Themes were then generated based on these codes, and the meanings and implications of the themes and codes were discussed. Lastly, the themes and codes were quantified and visualized to make the results more intuitive for comparison and discussion.

Results

Here, we discuss the differences that arose amongst the ten faculty members' understanding of creativity, and their choices of teaching methods, from the perspective of

their cultural backgrounds. In the quotes[1] we cited from the interview transcription, we use italic words in the brackets for clarification purposes, for example, "*It was the teachers who made it [learning] all interesting*." In addition, any "…" (ellipsis) in the excerpts indicates an omission of or a break in the original transcription, and any capitalized "P" plus a number inside a pair of parentheses, e.g., " … (P1)", indicates which participant spoke, explained, or commented.

Overall, from the interviews, we found that the faculty shared *similar perceptions and views of the importance of creativity* despite differences in cultural customs. They all defined creativity as a competency to demonstrate a "different thinking" mindset or propose novel ideas, methods, or solutions. They used some common methods to promote active learning. For example, they all loved to discuss with students, and many of them used group work in assignments. Their teaching, however, differed in using traditional teaching methods. For example, while Asian-reared participants preferred to ask direct questions to students, the U.S.-reared faculty members used lectures and teacher presentations more than their Asiareared colleagues did.

Definition and Importance of Creativity

Participants from either North American or Asian countries shared similar perceptions of creativity. Table 2 is a frequency count and comparison of their definitions of creativity. The faculty members defined creativity mainly according to two aspects: (1) new things or ideas and (2) problem-solving ability. Firstly, they believed that creativity meant thinking or making things new or "*have never existed* (P4 from Asia)." This novelty requires engineers and engineering students to "*think out of the box* (P1 from Asia)," "*have new ideas, approaches, and ways to do different things* (P5 from Asia)," and "*think about things in a non-traditional way* (P6 from NA)." To illustrate these points, P9 (from Asia) provides an example using kitchen and food as metaphors,

> *You can go to kitchens and bring different types of food together. We don't invent anything, but we may get them [food] by putting a Thai kitchen and an Italian kitchen together. They both exist, but you figure out what comes out when they [are] put together.*

Secondly, our participants viewed creativity in terms of problem-solving ability. Their understanding differed on this aspect. NA-reared participants believed that creativity meant solving a problem differently or with available resources or tools, indicating a focus on probability and possibility. For instance, P6 (from NA) argued, "*There's not always one right answer*;" P10 (from NA) commented, "*Creativity is being able to see things in a different way*;" and P8 (from NA) commented that creativity meant engineers or engineering students should "*use resources and tools available to you to address problems*." Asia-reared participants, however, deemed that creativity meant "*Transfer [knowledge] to application* (P1 from Asia)" and bringing benefits to society, indicating a more practical emphasis on the role

[1] The quotes in the current paper may be partially overlapped with those reported in another paper that we published in the International Journal of Engineering Education [61] as these quotes are from the same data.

of creativity. P1 (from Asia) explained what a creative "transfer to application" looked like in reality,

> *Once I visited a small startup in San Francisco. They did similar work that I teach in classes. It was just three people who started in an abandoned warehouse. It was a simple idea, but it worked. A few years later, that startup was bought by Monsanto for a billion dollars*.

Meanwhile, the solutions should be "*applicable to different places* (P1 from Asia)" and "*have a positive effect* (P9 from Asia)."

In addition, all participants believed that creativity is vital to engineering. The world of the future is full of various uncertainties and complex problems, but creativity is the best weapon to combat these challenges; as P8 (from NA) expressed, "*Creativity allows engineers to remove themselves from certain sets of confines, boundaries, or limits*." P9 (from Asia) held that "*we learn so many engineering tools and methods. But if you only stick to what you are taught, then nothing will improve. So you need to go a little bit further*." With creativity, engineers and engineering students can "*solve grand challenges and big problems* (P3 from Asia)." P4 (from Asia) provided us with an example of the Apple Watch to show how this kind of solving process could happen,

> *Back to 10 years ago, diabetes patients should take their blood samples each day … but these days, the patients can just apply the pinch on their screen. They can continuously measure the glucose level in a minimally invasive method*. This example demonstrated how creativity played its role in problem-solving, illustrating what significant changes the integration of creativity, engineering, and technology can make to our lives.

Finally, individual participants had other choices of teaching methods. One participant (P6 from NA) deemed that "*being able to work with one another*" demonstrates being creative. Another participant (P3 from Asia) believed that expression without judgment indicates creativity. She explained,

> *Expressing yourself without any judgment, or it's a way of expressing your emotion at that particular time frame. How do you feel? How can you express something that can give joy to someone who's, who's watching it, or which could … how can you share your joy with people around you?*

Choices of Teaching Methods

Participants' choices of teaching methods for knowledge construction and creativityfostering in the classroom had both similarities and differences (see Table 3).

Firstly, Asia- and NA-reared participants diverged on selecting traditional teaching methods. Here, we define the term "traditional teaching methods" as teacher-centered instructional methods that involve little student participation (as defined by [62]), such as a lecture presentation solely led by an instructor. Four NA-reared faculty members mentioned using lectures or presentations, double the number of their Asia-reared colleagues. Some of them used "*PowerPoint presentation* (P7 from NA);" some used "*probably 60% PowerPoint, 40% blackboard working problems* (P2 from NA);" and some "*spent a lot of time on my slides in terms of making them visually sophisticated* (P8 from NA)." For Asia-reared

participants, digital slides were not always an option, "*I use combined slides and you know, whiteboard or blackboard. So sometime, you know, no slides, but you know, just use a board* (P5 from Asia)." While both sides would assign individual work to students, NA-reared faculty members mentioned more other teaching methods, such as "*teach with a document camera … [That is how] I teach, so I can face students while we go through the notes* (P6 from NA)," "*all lectures are organized around a couple of learning objectives* (P8 from NA)," "*use some sort of quiz or just some sort of question* (P8 from NA)," and "*use images and analogies and things like that … presented in a more graphic way, rather than text* (P7 from NA)."

Secondly, participants shared commonalities in using active learning methods, such as discussion and group work in face-to-face and online classes. For example, P1 (from Asia) would start his class by "*having a casual discussion [with students]*." P10 (from NA) would "*go off of … I try to engage the students in some back and forth and discussion on material*." P4 (from Asia) used "*small group discussion*" in her face-to-face classes, and P8 (from NA) would use "*breakout discussion groups at least once, sometimes twice*" in his online classes. Group work was also in the teaching toolkit of these faculty members. P4 (from Asia) claimed, "*We usually assign a group called student learning process to collaborate. To some collaborative work, I think [group] is really important, especially for these biomedical engineering students*." P7 (from NA) would have students "*meet as a group*" and so did P10 (from NA) whose students "*work on problems as a group*."

Discussion

Overall, as engineering instructors in a university, our participants' definition of creativity was very basic. Unlike researchers working on creativity studies who would consider multiple characteristics of different people such as openness, risk-taking, flexibility, or challenges to authority as essential manifestations of creativity [17], our participants simply defined creativity as being new and problem-solving or as the ability to propose new ideas or solutions. Their understanding partially corresponds to previous researchers' definition of creativity (e.g., [63], [64]). Though divergent on specific understanding (for example, what "problem-solving" means), our participants still shared a similar perception of creativity regardless of their cultural backgrounds. In their minds, creativity needed not only to be something new but also to be something that could solve real-world problems or bring benefits to society. This understanding aligns with a wide consensus that creative ideas must be both new and useful [65]. In addition, according to our participants, being creative could also mean being empathetic or collaborative, which are essential components of design thinking principles [66]. To what extent can we feel what others feel? Will our creativity make others feel comfortable? How well can we collaborate with others? How creative can our ideas or solutions be through our collaboration with others? These questions were also asked by previous researchers [67].

As for participants' teaching methods, traditionally, Asian education, especially EastAsian education, is test-centered [68]; and teacher-centered teaching methods are widely used [69]. According to our data, however, NA-reared participants mentioned using lectures or presentations in classes *more* than their Asia-reared colleagues. We speculate that Asia-

reared faculty members might be eager to show students that they, as foreigners in the United States, were creative teachers through using novel teaching methods (at least in their eyes) in classes and avoid using those traditional teaching methods (at least in their eyes); in contrast, NAreared faculty members, as native residents, did not need to demonstrate their creativity using intricate teaching methods as much as their Asian colleagues did, and therefore, they would choose more regular or traditional methods that do not demand more delicate instructional design ideas or teaching skills to save time or energy. This speculation is supported by a previous research study discussing the correlation between originality and usefulness of ideas proposed by U.S. expatriates to China [70]. In their study, Hempel and Sue-Chan found that, as U.S. expatriates stayed longer in China, the *originality* of their ideas would gradually reduce, but the *usefulness* would increase to make their ideas fit the local situations better. If we see the Asia-reared faculty members as expatriates from Asia to the United States, we may infer that early-career Asia-reared faculty members might choose non-traditional teaching methods in the early years of their careers to show their creativity and in exchange for better teaching outcomes, but they might switch teaching methods to those more practical in the following years of their career, and finally, they would reach a balance between intricacy and practicality in selecting their teaching methods.

Conclusion

This study provides us with knowledge about how cultural backgrounds might impact faculty members' perceptions of creativity and their preferences of choosing or using creativity-fostering methods in their teaching. This exploration allows us to meet faculty where they are and develop an effective intervention to help faculty build competency in integrating evidence-based creative thinking practices and exercises into their engineering teaching. The intervention should, in turn, help engineering students engage more with creative concepts/practices/activities in engineering classes.

Though this preliminary study investigated how cultural backgrounds connect to earlycareer engineering faculty members' understanding of creativity and selection of teaching methods, several important aspects have not yet been explored. One aspect, for example, would be how these faculty members' growth or learning experience in their native countries or cultural environments impacted their teaching philosophy and strategies. Future researchers may find it valuable to dig deeply into this research topic. Our previous study found that early-career faculty members learned to teach from their previous advisors or even high school teachers in their home countries [61]. Knowing how these faculty members experienced the learning in their native cultural environments might help us better understand why they chose a teaching method and how we can improve their teaching skills. Another area for investigation would be how these faculty participants *implement* creative thinking and practices in engineering classes. How consistently do they implement teaching methods with what they claimed to do in the interviews? How differently do Asian-reared faculty members teach in contrast to their U.S.-reared colleagues? These questions will be our subsequent research foci using class observation data. A further extension of our research would be to expand the current project to more universities and conduct longitudinal studies – either quantitative or qualitative.

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Tables Table 1

Participants demographic information

P#	**Gender**	**Continent of Birth and Growth**
P01	M	Asia
P02	M	North America
P03	F	Asia
P04	M	Asia
P05	F	Asia
P06	M	North America
P07	M	North America
P08	M	North America
P09	M	Asia
P10	M	North America

Table 2

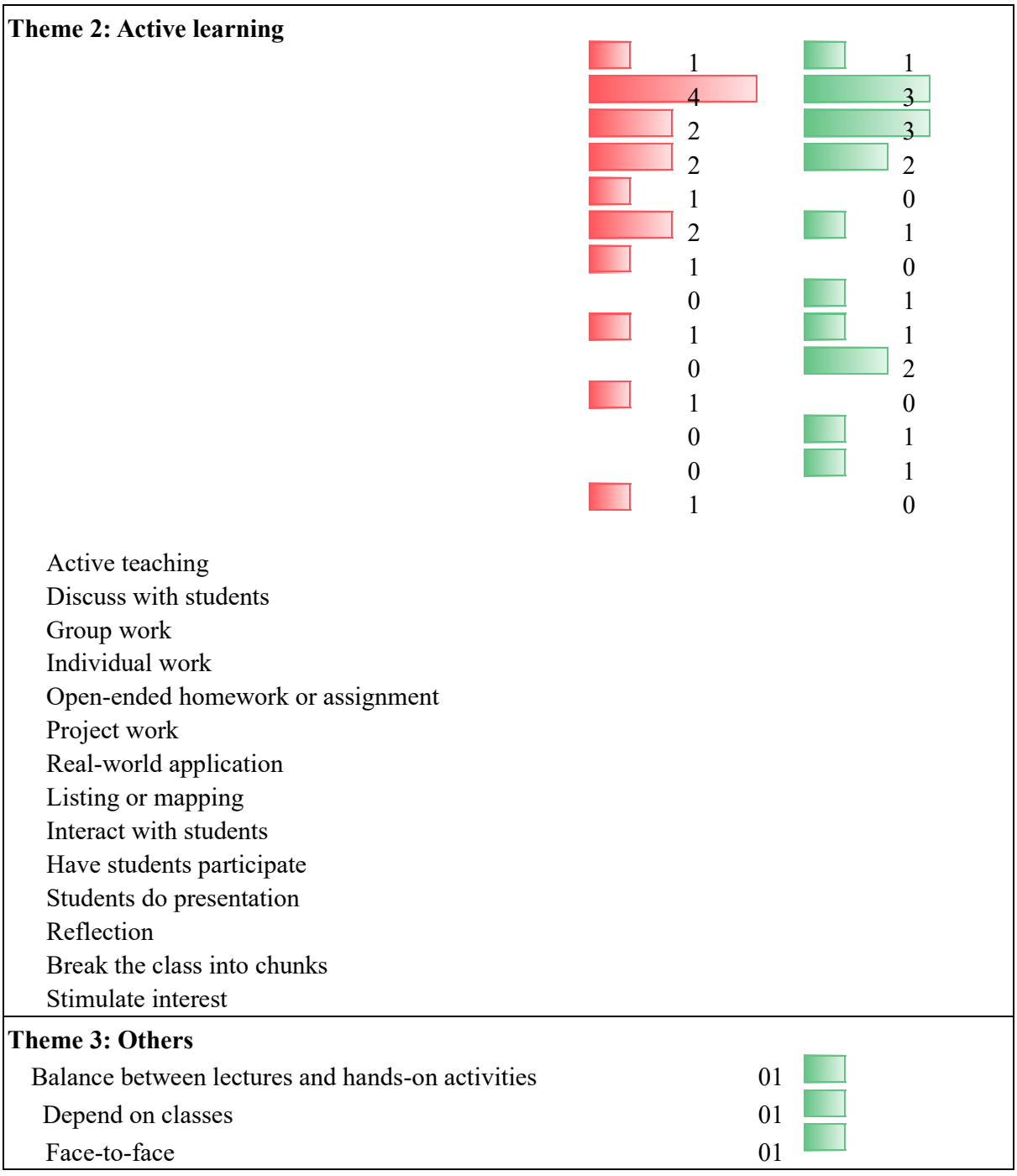
Frequency count comparison of participants' definitions of and perceptions of the importance of creativity by their continents of birth (the numbers in the table indicate how many participants in each code)

Definition of Creativity	Number of Participants	
Code	**Asia**	**North America**
Theme 1: New things or ideas		
Do something new	3	2
New ideas	0	1
New ways of thinking	2	3
Think outside the box	0	2
Theme 2: Problem-solving ability		
Bring benefits to society	2	0
Integrate knowledge	0	1
Solve in different ways	0	3
Solve problems using resources and tools available	0	1
Transfer to the application	1	0
Theme 3: Others		
Expression without judgment (empathetic)	1	0
Work with others	0	1

Table 3

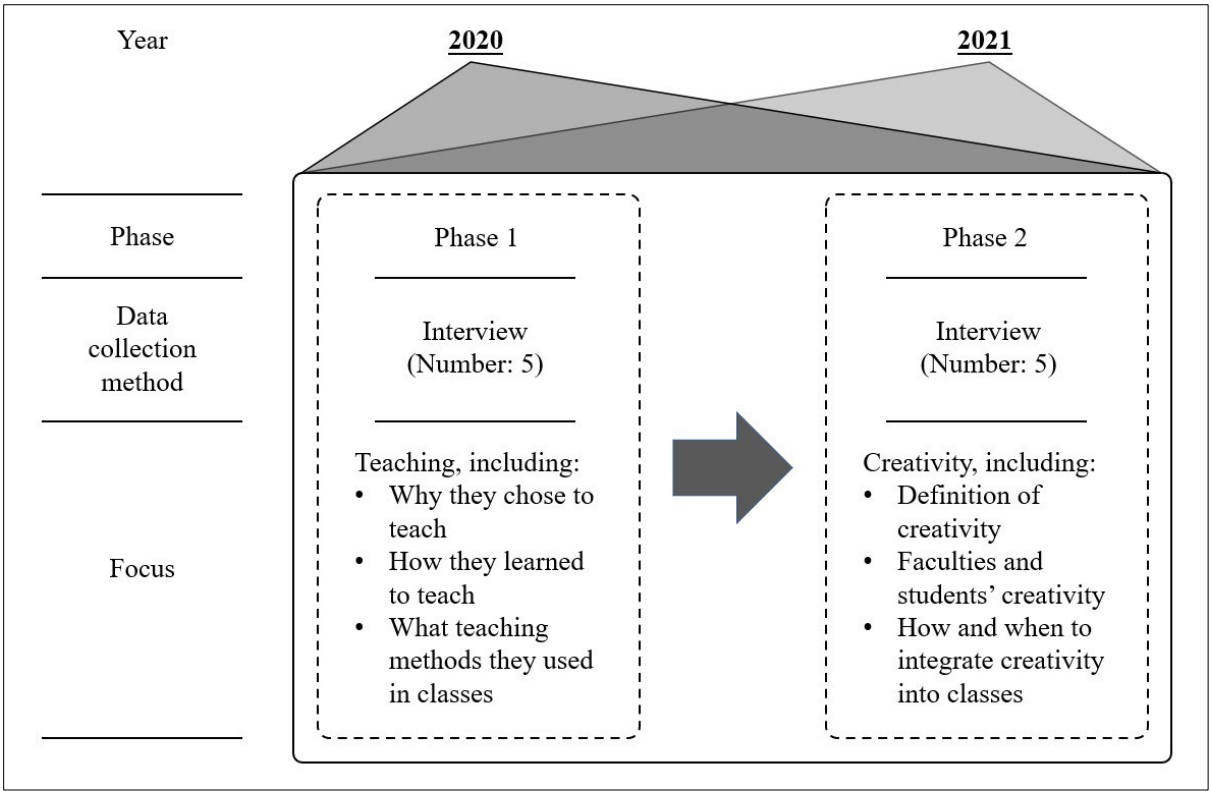
Frequency count comparison of participants' selections of teaching methods in the classroom by their continents of birth (the numbers in the table indicate how many participants in each code)

Choices of Teaching Methods	Number of Participants	
Code	**Asia**	**North America**
Theme 1: Traditional learning		
Lecture or presentation	2	4
Clear learning objectives	0	1
Ask questions	2	1
Extra credits	1	0
Use textbook as complementary	0	1
Use quizzes or questions	0	1
Teach with a document camera	0	1
Use analogies or metaphors	0	1
Use graphics	0	1



Figures Fig. 1

Diagram showing that participants from years 2020 and 2021 experienced the same data collection process from Phase 1 to Phase 2.


Year
2020
2021
Phase
Phase 1
Phase 2
Data collection method
Interview (Number: 5)
Interview (Number: 5)
Focus
Teaching, including:
• Why they chose to teach
• How they learned to teach
• What teaching methods they used in classes
Creativity, including:
• Definition of creativity
• Faculties and students' creativity
• How and when to integrate creativity into classes