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Architecture students' conceptions, experiences, perceptions, and feelings of learning technology use: Phenomenography as an assessment tool

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Abstract

The primary purpose of this phenomenographic qualitative study is to identify a group of second-year undergraduate architecture students' conceptions of learning technology use. The secondary purpose is to examine students' learning experiences, perceptions, and feelings of technology use in an education course. Data were collected over a week by individually interviewing 15 architecture students, who were becoming teachers of architecture. Each 20-min individual interview was audio-recorded, transcribed verbatim, translated into English, and analysed to identify descriptive categories of the students' conceptions of learning technology use. The six descriptive categories were: learning online; searching for information and knowledge, defining social media connectivity, exploring a virtual place, designing a model house, and transferring knowledge and understanding. Most architecture students expressed the technology-integrated lessons were interesting. The architecture students perceived educational games as the most useful teaching tools in their future classrooms. The study implies phenomenography can be used as an assessment tool to identify students' conceptions and characterize their structural aspects, which may be used as curriculum frameworks to design content that moves architecture students from the periphery to the core of the subject.

Keywords Learning technology · Phenomenography · Higher education · Architecture students

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1 Introduction

Contemporary youth spend an enormous amount of time surfing the Internet for social and academic reasons (Joshi et al. 2019). Besides, online learning has been growing steadfastly for the past two decades (Martin et al. 2020). Although current students use technology more than any previous generation, such use is notably absent within the classroom (van Broekhuizen 2016). If students do not learn with and through technology, it is probably more due to the lack of meaningful integration of it by the teacher, than the lack of student technological abilities (Wang et al. 2014). Various barriers prevent successful technology integration into teaching and learning environments (Bingimlas 2009), despite its proliferation (van Broekhuizen 2016) and access to a technology-rich environment (Schoepp 2005).

Focusing on positive correlations between the characteristics and their use of technology, Thompson (2013) and Bolaños and Salinas (2021) argued that students today approach learning differently. Educators also use new approaches to cater to individual needs (Engelbrecht et al. 2020). Kolikant (2012) observed a disconnect between theory and practice on the efficacy of learning technology and implementing tools in higher learning institutions. Some ways to narrow the gap between theory and practice are to incorporate students' conceptions of learning technology into the curriculum, keeping abreast of current technological approaches in the field of study, and enabling students to become better prepared for higher education and employment (Lawless and Pellegrino 2007).

2 Purpose of the study

Augmenting student learning technology experiences in an education course requires the exploration of the beginning, developing, and developed conceptions (Thagard 1992). This study focuses on first, becoming aware of student knowledge and abilities before instruction. Technology educators should recognize the value in incorporating students' experiences with learning technologies explicitly into the design and implementation of the curriculum. This approach to teaching enriches learning. It values conceptual empathy and cares for students' prior experiences, knowledge, understanding, and abilities. Using phenomenography as the theoretical and methodological framework, we explored how architecture undergraduate students, preparing to be future teachers, conceptualized learning technology use; aiming to guide the future direction of the course and help make decisions for widening the scope of learning technology use, particularly concerning the needs of architecture students. This study also examined the students' experience, perception, and feeling of learning technology use in the classroom, and the types of technology tools that these students would use when they become teachers in the future. This purpose can help students perceive how useful these technology tools are and inspire them to embed in teaching and learning.

3 Literature review

3.1 Learning Technology in Architecture

Recent increases in computing power have led to developments in cognitive psychology and artificial intelligence, which are the basis for new tools, that support teaching and evaluation of architectural design (Guney and Geiger 2015). Advances in technology also place new demands on the construction industry, including progress in software, construction, and assembly methods and materials. Practices in architecture are adapting to the changing technology, working more efficiently and effectively (Colomina 2012). Additionally, information technologies present new opportunities and challenges to the architecture profession (Andenas et al. 2012). The industry and market are moving forward to meet societal needs, but there is concern that trainees are not keeping pace with relevant education (RIBA 2011). Allen (2012), however, points to an advantage for contemporary learners; as computers are integral to the architecture design studio, and the relationship to digital technology is strong due to access to inexpensive, easy-to-learn digital technology so that a new technology-savvy generation can use them more efficiently and effectively. He elaborates:

> A new generation of architects who have been educated entirely within the digital regime no longer need to think about how to use an unfamiliar tool; they can now focus on what to do with that tool. Its logic has been fully absorbed into contemporary work routines and habits of thought in the field of architecture. As a result, designers are now turning their attention to the computer's strategic and operative potential. The forms of practice that digital technology enables are as important as the formal languages it makes possible (Allen 2012, p. 9).

Pre-university, vocational, and undergraduate architecture education courses should, therefore, mirror the architecture field; learning takes a societal character and social transformation (Lave and Wenger 1991), with the learner entering a community of practice with access to its privileges - resources and discourse - for productive activity. Through learning to employ conceptual and physical tools, at the same proficiency used in a field, a learner moves into that community and its culture. This idea of community practice generates the third space in Vygotsky's (1978) social character of learning. For active learner involvement with learning technology, pedagogical structuring ought to point, and pave a path, to the communities of practice. Therefore, reasonable workplace indicators suggest the use of authentic activities and contexts of a domain's culture. For example, if teachers act as practitioners, representing the community in school and university class environments, they can shepherd students to connect to authentic and meaningful applications of those activities and move them from the periphery to the core.

3.2 The variation theory of learning

The variation theory of learning (Marton 1981) entails developing a relational meaning between learner and content through discourse, allowing the learner to become more knowledgeable in a domain. This development implies a qualitative change to a more complex understanding of a phenomenon within a learning context, involving a shift in learner thinking, with this move between different perspectives shaping understanding of the concept. Thus, a learner's conception of a phenomenon is provisional and qualitative. The variation theory of learning espouses instead of focusing on dispelling their theories, as conceptual change does, students should be taught to distinguish contexts of knowledge use. Hence, rather than the focus on conceptual change in social areas, such as conceptions of learning technology use, where there is no right or wrong answer, phenomenography is one of conceptual dispersion, where learners should add to their repertoire of knowledge. Students should explore the outcome space.

Phenomenography, grounded in the variation theory, embraces qualitatively different ways of experiencing or conceptualizing a phenomenon, clustered into descriptive categories (Marton and Booth 1997). The experience, or conception, involves one or more relations between the person (subject) and the content (object) and is, therefore, two-dimensional. One dimension focuses on how a learner understands the structure of the content, and the other on the content itself - the referential aspect. The relational quality of conception depends upon how a person experiences the content within a context or situation.

Each descriptive category is delimited to internal and external horizons (Bruce et al. 2004). The internal horizon represents the meaning, the focus of the phenomenon, which comes to the foreground. The external horizon represents the background; essentially, the perceptual boundary, associated with how the learner sees. For example, students, experienced in sharing information, attributed to the internal horizon, would see a website as a receptacle or virtual platform, enabling first the thought and then the act, as the external horizon.

4 Research questions

Founded on the variation theory of learning, the following research questions frame this study:

1. What are the second-year undergraduate architecture students' conceptions of learning technology use?
2. What are students' learning experiences in an education course?
3. What are their perceptions and feelings on the use of technology in their careers in the future?

5 Research design

Phenomenography is a coherent, distinct qualitative research paradigm, that aligns with the variation theory of learning (Ashworth and Lucas 2000). It is an iterative, interpretive research approach, with the potential to reveal the qualitatively different ways of experiencing a particular phenomenon, within a reasonably sized target population, that can reflect finite variation (Marton and Booth 1997). Phenomenography is a method that has been widely used in educational research (Boda 2019; Hathaway and Fletcher 2018; Kyriakoullis and Zaphiris 2017). It takes a second-order research perspective, involving a researcher making statements about other individuals' personal experiences of the world and attempting to see the world through their eyes (Marton 1981).

Phenomenography involves exploring individuals' conceptions of a phenomenon, such as learning technology use. Conceptions may reflect differences between individuals or within the same individual. These differences of conceptions are referred to as inter-variation and intra-variation, respectively. Individuals' responses to questions are repeatedly read reflexively to discern patterns or develop descriptive categories. Responses are interpreted based on how individuals conceive a phenomenon, rather than imposing preconceived categories. Inter- and intra-variations, when grouped, reveal a finite, or limited, number of qualitatively different ways of reflecting upon a phenomenon. Some studies confirmed that a researcher can identify a limited number of descriptive categories, based on the various ways individuals express their conceptualization of a phenomenon (Hodgson and Shah 2016). The conceptions are limited, because a perceiver's experiences, formally learned concepts, the phenomenon, or the context itself, and, probably, biological attributes of the individual for conceptual processing constrain their conceptualizations (Linder and Erickson 1989).

5.1 Context of the study

The "Innovation and Information Technology in Education" course is compulsory for undergraduate students in the Faculty of Industrial Education and Technology at the second author's institution. The course aims at (1) identifying the opportunities that innovation and information technology improve the quality of learning; (2) discussing the issues innovation and information technology pose in education; and (3) evaluating innovation and information technology. This course has three hours of instruction per week for fifteen weeks. Thus, it is believed that students would gain sufficient experience in the use of learning technology.

5.2 Participants and demographics

Phenomenographic studies usually involve small groups of participants. Purposeful sampling consists of a group of at least 15 individuals from the same population to allow meaningful interpretation (Trigwell 2000). Concerning insights about what learning technology use means to the group and their experiences in technology use, a sufficient sample size to represent the learning technology class used here was 37 s-year undergraduate architecture students. All students are Thai and come from various parts of Thailand. There were 25 females and 12 males in the class. Their age bracket was 18–20. Most had smartphones and laptops; could use software for tasks, such as word processing, spreadsheets, and construction of PowerPoint presentations. They were familiar with AutoCAD and Google Maps. This research was supported by King Mongkut's Institute of Technology Ladkrabang (Thailand). The rights of students were protected, students were advised that their opinions would not be linked to their identities, and interview data were anonymized.

5.3 Data collection

Data collection in phenomenographic research is exploratory, attempting to capture and describe participant expressions in words that accurately describe the different ways a group of participants experienced a phenomenon. Interview questions are of the second order, focusing on the relational meaning between subject and object (Cope 2004). Fifteen students from the learning technology course who volunteered for this study were individually interviewed for at least 20 min over a week. Seven out of fifteen participants were male and eight females. The interviews were fluid and open-ended focusing on the phenomenon of learning technology use. The interview started with a broad question that attempted to stimulate or elicit students' insightful responses about their conceptions of learning technology use. Based on an individual's answer, a sequence of questions then probed his or her deeper thinking. For example, the questions posed at the interview in this study were: What are your experiences with learning technology? How do you think you will use learning technology in your future career?

A conversational interview puts the learner at ease, providing insights into learning experiences and conceptualizations. The interviewer constructed follow-up questions, using only terms used by the interviewee in their responses. In other words, the interviewer analysed the responses and constructed follow-up questions, based on learner experiences.

5.4 Data analysis

Following Cope (2004), we used the structure of awareness as the framework to analyse "how" the students experienced learning technology use. To discern this structure, a relationship with the data was formed, which acknowledged variation in the data, by ignoring influence from the researcher's prior knowledge of the phenomenon in the analysis (Cope 2004; Marton and Booth 1997). In our study, data on how a group of undergraduate architecture students experienced and conceptualized the phenomenon of learning technology use, in qualitatively different ways. The data underwent inductive analysis, through an iterative and interpretive process. This analysis allowed us to understand each expression of the student based on the way they experienced and conceptualized the phenomenon (Booth 1997). Student expressions were considered at face value (Richardson 1999) and combined to form a pool of meanings to depict variation in conceptions of the phenomenon of learning technology use based on their experiences.

We read students' expressions and color-coded similar meanings, assigned a label for each category and sub-category, and tallied the frequencies (see Table 1 in the Results and Discussions section). The meanings were analysed by the researchers and the codes were agreed upon between them after the discussion to meet consensus.

5.5 Rigor and quality of Phenomenographic research

Each phase of a phenomenographic study is executed based on the tenets established by the phenomenographers to enhance rigor and quality (Cope 2004). Second-order questions generate other people's conceptions from their perspectives and experiences (Marton 1981). The researcher focuses not on the subject or object of the study. Rather, he looks at the relational meaning between the subject (epistemology/how) and object (ontology/what). The researcher suspends knowledge in all aspects of research. Thus, his/her voice is intricate to each phase of research. A commitment to reflexivity throughout the research process is significant to ensure credibility.

Data analysis involves identifying and clustering similar conceptions from data, with each cluster denoting a descriptive category. We interpreted and discussed each descriptive category, using excerpts taken from the interview scripts, as supporting empirical evidence. In other words, the descriptive category must be derived from the data, not deductively imposed from an external source. The researcher lifts meanings from the excerpt, not bring her ideas, and conveys the intended meaning of the participant. The data analysis process adds trustworthiness to this research.

Marton and Booth (1997) outline three criteria for evaluating the quality of the findings or the outcome space that constitute the descriptive categories: (a) Each category is distinctive, conceptions within it point to a singular meaning; (b) The categories are optimal and parsimonious; (c) The relation between the categories is clearly stated. Highlighting, representing, and reporting results must have meaning-linguistic congruence. Thus, the language used to convey the meanings to the reader is referred to as the intentional-expressive approach, which contributes to the quality of research. Empathetically and consciously reflecting on the use of language to explain the intended meanings places as clearly as possible integrity and trustworthiness in the reporting and discussion of the findings.

Although we may not want to use quantitative terms such as validity and reliability, we can unhesitatingly translate some general principles of qualitative research to phenomenography. Borrowing from Flick (2018), the study's consistency was established by determining inter-rater reliability. The research claims and transcripts of student-researcher conversation excerpts were sent to two external, trained phenomenographic researchers to check the fit between each category of description and excerpt as supporting evidence.

Table 1 Analysis using the structural awareness framework ascribed to learning technology

No.	Descriptive Categories of Conceptions	n	Internal Horizon (Values)	f	External Horizon (Context) Delimits learning technology to the…
1	Learning online	13	Distance learning	4	Various forms
			Independent learning	2	
			Blended learning	4	
			E-book learning	3	
2	Searching for information and knowledge	10	Learning more efficiently	6	Potential benefits
			Accessing knowledge for better understanding	4	
3	Defining social media connectivity	10	Equity	1	Attributes of social media
			Communication	6	
			Express views	3	
4	Studying a place virtually	2	Google Maps	2	Virtual reality
5	Designing a model house	3	Animation software	1	Software for design
			AutoCAD	2	
6	Transferring and understanding knowledge	6	Transfer knowledge	1	Learning theories
			Understanding	3	
			Transfer knowledge + understanding	2	

6 Results and discussions

6.1 Analysis using the structural awareness framework ascribed to learning technology

Table 1 represents the results of the phenomenography. There were six descriptive categories of meaning that the architecture students ascribed to learning technology use. Based on these categories, we generated structural awareness (the internal horizon or the values, and the external horizon that defined the boundary) from the student learning technology experience data. We supported each descriptive category and corresponding internal values with representative excerpts. We interpreted and discussed each descriptive category with relevance to architecture students to develop a deeper understanding of learning technology use, grounded in structural awareness. Pseudonyms were assigned to the students.

6.1.1 Descriptive category 1: Learning online

Of the 15 students, 13 subscribed to online learning, attributing four values: distance learning; independent learning; blended learning; and e-book learning.

6.1.2 Distance learning

Four students valued distance learning.

> …. the video of class teaching was good for distance learning and provided the opportunity to learn, for students who live far away or in rural areas. Students could learn through the online materials, such as ……… (Mai)
> …. in online classes, we could learn from home. Students could learn from YouTube videos or related websites, which are sources of knowledge. (Cam)

It was not surprising that architecture students considered distance learning as a viable way of studying in the age of technology. Students viewed distance learning in two ways: a learning opportunity for those living far away (e.g. Mai); and a learning opportunity for those who preferred not to be in class (e.g. Cam). Von predicted the future of learning:

> The future will have better and more advanced technology (including internet in the countryside). So, I hope to use this technology to teach there. So, we can use video calls to teach, like distance learning. Students interacting online in real time. Education technology can help students to meet educational targets; the learner benefits from technology. (Von)

Aware of the power of technology for communication, all four students suggested that schoolchildren can learn from home when too far away, not able, or not inclined to attend. Whatever the reason, students can reach their goals. In line with student thoughts on the use of learning technology tools, Harasim (2000) reminded educators about the current knowledge economy: web technologies have made online learning increasingly accessible, open, and flexible, supporting new pedagogical models. Bozkurt et al. (2015), noting that the revolutionary digital knowledge age enabled faster human communication and information proliferation, stated a need for a parallel paradigm shift in education. Thus, these students identifying options for, and positive feelings toward, learning as a result of technology were in line with current thought.

6.1.3 Independent learning

Two students valued online learning for independence.

> Learning through an online application and learning face-to-face had different benefits. Learning through an online application meant learning by yourself, and you can choose what you learn. In class, you learn by following a curriculum. The teacher follows the curriculum and you learn only what they teach you. You can be more independent online, and learn with more depth. (Tom)

Tom reasoned that, in independent learning, one can specify what one wants to learn - not constrained by, or limited to, a curriculum. Rather, one can explore widely or gain deeper knowledge. Shimakawa and Phuong (2016), however, observed not all students preferred self-study. Unrestricted by curricula or teachers, Tom preferred self-motivated and self-regulated learning (Zimmerman 2002). We can understand Tom's preference, because we know tools, such as the internet, electronic whiteboards, and video equipment, promote independent learning. However, Tom was not aware of the meaning of independent learning, because he referred to it as self-driven, rather than the teacher facilitating it or having any part in it. The educator is integral to independent learning, gradually building a repertoire of strategies for students to increasingly take over responsibility for it. Educators encourage students to become independent by modelling learning behaviour and providing a supportive scaffold. Gradually becoming more independent, learners need assistance and feedback, not only on the results of their learning, but also on the process itself (Artelt et al. 2003).

6.1.4 Blended learning

Four students valued blended learning for participating in-class activities.

> Using internet technology to submit work online and students can …… Then, the teachers can mark them online as well. So, it's quite convenient for both students and teachers. You don't need to print it on paper, which saves time and cost. (Len)
> Many students have smartphones. They can use them to learn outside the class as well, such as in online exercises after taking each lesson in class. (Mike)
> Students who didn't understand the lesson can learn through online lessons, and search for more knowledge online to help us with assignments and … Learning is not just remembering; we should learn by doing. We need to test

> theories, to help us understand them better. Educational media just provides guidelines for learning. (Ohn)

Students suggested learning was not only face-to-face but augmented with online facilities. Blended learning, following Graham et al. (2005), is the convergence of traditional face-to-face and distributed learning environments; it is learning by combining diverse technologies and tools in face-to-face classes and outside the classroom, using only collaboration.

Technology enables new teaching and learning patterns (So and Brush 2008; Lopez-Perez et al. 2011), but learning requires more flexibility (Graham et al. 2005). To ascertain the optimal mix of technologies and teaching activities López-Pérez et al. (2011) proposed educators consider student benefits, teaching methods that motivate learning, and levels of student satisfaction.

6.1.5 E-book learning

Three students valued digital reading.

> We can read a book online on laptops or smartphones. Electronic books have links to related websites to explain that topic further, and also pictures or videos to explain or to show us examples, not in the text. (Eva)

Eva's statement was aligned with Landoni and Hanlon's (2007) description of e-books and discussion of the positives and negatives of electronic reading and paper books. Jeong (2012) compared electronic and paper books for reading comprehension, eye fatigue, and perception. Eva and her peers need to understand these points, to choose e- or p-books appropriately. Garrod (2003) observed that new media, e.g. books, added to our choices, rather than substituting one form for another; however, Kelly (2006) anticipated that, shortly, "all-new works will be born digital" (p. 43).

6.2 Descriptive category 2: Searching for information and knowledge

6.2.1 Learning more efficiently

Six students viewed online learning as more efficient.

> We can search for information in this big online world and collect information from around the world. So, we are not just in a small room anymore and we can learn more efficiently. (Mai)
> Educational videos and websites allow us to learn more from material around the world. I will assign online searches for my students, so they can learn outside the classroom as well. For example, …………… (Eva)
> We can learn more through technology, especially activities that we couldn't do in the real life without it. For example, ………. I regularly use Pinterest, to see architectural photos and get inspiration to find out more on a deeper level to develop my own work. (Mike)

These students suggested knowledge does not reside within the four class walls, or a country, because of the internet. For example, Mike showed how he will use the internet: to study astronomy topics, inaccessible without technology, and to search for ideas on architecture through interesting photos. Both examples showed Mike's desire to find information at a deeper level to develop his interests. Thus, an educator may assign work, only possible with technology, and search the internet for project-based topics and issues. With the latter, students can follow interests and passions, not only through reading materials but also by interacting with local community elders and global experts (Means et al., 2010). Such real-world activities empower undergraduate students on a learning technology course, immersed in technologies, that they will use as future architecture teachers.

6.2.2 Accessing knowledge for better understanding

Four students used online learning for better understanding.

> Yes; I found that I can learn more through websites. I can search for more information, if I don't understand what the teacher has taught us in class. (Ohn)
> I use Google to search …… It's easy to understand and I get lists of related websites, images, and videos. It's a wonderful tool to open these sources of knowledge. So, we can search …… Especially, videos with pictures and sound are very interesting media in teaching. If I don't understand the lesson, I would like to learn more from videos, which are not boring. So, it's not limited only to listening to the teacher or reading books. (Len)
> It's easier to understand than just using the text. Or we can show a video before we start the lesson, to guide the students in what we are going to learn. (Eva)
> I use Google and Pinterest to search for information or for examples of models, that we can apply to our work. (Sam)

These excerpts suggested that students use internet tools to fill gaps, confirming reports from Mayer and Moreno (2002). Examples of simulations and animations, that illustrate physical or explanatory models, are plentiful on the Internet - architecture is no exception. In this technology era, students do not need to depend on teachers, because, on the internet, they can study the same topic for deeper understanding by reading material or connecting with experts. Len's claims were consistent with success, in using learning technology, being dependent on the relationship between the technology and the environment, where it is used, along with an instructional need not met by traditional media (Breslow 2007).

6.3 Descriptive category 3: Defining social media connectivity

Ten students contended social media is part of learning for three reasons: equity; communication; and the expression of views.

6.3.1 Equity

One student valued social media to communicate with students far away, so that all have equal opportunity.

> Learning through video calls or Skype (video conferencing) saves cost and time in travelling. So, all students can learn, even though they live far away in the countryside. Everyone gets knowledge, and they are equal in learning. (Von)

Von noted that technology made all equal. Equity and excellence are contemporary forces and foci in education (ISTE 2016 2017). The National Science Foundation instituted the Innovative Technology Experience for Students and Teachers program to reach all students, including the unreached, underrepresented, and underprivileged (NSF 2017). For quality assurance in college and university education, including teacher education, the Council for the Accreditation of Educator Preparation (CAEP) and the European Association for Quality Assurance (ENQA) called for the integration of learning technology into teacher education courses. Pre-service teachers are expected to demonstrate evidence that they know and can teach using, learning technology.

6.3.2 Communication

Six students valued social media for communication between students and teachers.

> In the past, we had to come to class. These days, we have social networks, and we can discuss our work online and ask questions and get answers immediately… I used Facebook to submit my assignments online every week, and I received feedback from lecturers; then, I could ask questions on how to improve my work. (Jan)

Andersson and Torgny (2000) reported that students were more comfortable with, and prefer, asking questions online than in class. Thompson (2013) found that students are adept at using communication tools, e.g., Line and Facebook, but less familiar with creating websites, which have a higher impact on studying (Lei and Zhao 2007).

6.3.3 Expressing views

Three students valued social media to express views.

> Software helps students to express our opinions! Without technology, students can’t answer questions or express opinions immediately. So, we will know if they understand the content or not. However, some students are shy. They aren’t brave enough to talk in front of the teacher or in class, because they

are nervous about what other people will think of them. Software that doesn't show the name of the person, who expresses the opinion, is a good tool. (Mike) In addition, I liked software that allowed us to express our opinions, where no one knows who wrote them. (Sam)

Both Mike and Sam were aware they could express opinions online. The students saw the value of expressing opinions anonymously. While we acknowledge their conditions for expressing views, it is also important to share what is learned in class openly, with names displayed. This can be achieved by creating a space for classroom discourse on a virtual whiteboard, to build a community of learners through reflective practice. This idea conflicted with interviewed students' wish for anonymity because the discussion thread reveals names and interconnected links, learners that are developing the community. Hence, the e-dialogue proposed here requires intellectual empathy and care from peers and students. Participants provide constructive feedback, mutual respect, openness, and readiness to see the viewpoints of others - all features of an established community.

Building a community of practice lies in the sociocultural theory of learning and development. It contends that all human development rests upon social interaction in cultural or historical practices, mediated by the use of cultural artifacts, tools, and signs (Jimenez-Silva and Olson 2012; Lave and Wenger 2001; Vygotsky 1978). Therefore, sociocultural theories of learning place language, culture, and, therefore, community front and centre in the development process, making them ideal organizing principles for architecture courses.

6.4 Descriptive category 4: Studying a place virtually

Two students valued virtual learning using Google Maps.

In my architectural design module, the lecturer gave the assignment to analyse a site. We needed to know the environment around it, so we had to find satellite imagery to assist us. Google Maps shows all the major locations in the world. This semester, we were asked to analyse a site near …… We used Google Maps to measure the distance from the proposed building to the system and between the surrounding buildings. We also used it to find out how to travel to that location. We wanted to know the sites of importance in that area and about prevailing wind, sunshine direction, etc. As you know, we can't take all of the students to the location, but students can use Google Maps, like a virtual world, to think about how to design a building in that area. It's part of the job. If we don't visit the real location, we can't design the building effectively. (Tami)

Students discussed Google Maps after some exposure to it in their architecture class. Tami stated virtually auditing a neighbourhood was a reliable, cost- and time-effective alternative to actual visits (Badland et al. 2010; Ben-Joseph et al. 2013; Clarke et al. 2010). García-Martín and García-Sánchez (2013) and Vandeviver (2014) observed students using Google Maps and showed its merits as a didactic tool in education (Ovidia 2012; Patterson 2007). For example, they observed that undergraduate students, instructed in Google Maps, could use their devices to select construction locations and explain the location suitability, or quickly consult Google Maps to rate certain features, e.g., house size. Google Maps is accessible to everyone, is easy to use, allows quick address location, and provides cartographic maps, augmented with digital information, and high-resolution aerial imagery (Pringle 2010).

6.5 Descriptive category 5: Designing a model house

Three students valued learning technology in designing a house model.

> I used software to design a house and hardware to print out a model. Using software for animation and printing models using 3D printers, I presented my work to classmates. I looked for any part of the structure that I can apply to my own design. I then presented and got a customer evaluation, along with the teacher and peer criticism or suggestions. (Lin)
> Yes, I have learnt about AutoCAD, to design and present a house or building model in the architecture subject. I used the software to present my idea to show people what the building I wanted to build would look like. (Mike)

Some students alluded to architecture-related technologies, such as AutoCAD and 3D printers, which helped them present their works precisely, as they would appear in reality. This follows Guney and Geiger (2015), who suggested the importance of teaching discipline-based, society-related technologies so that future teachers can represent the discipline and community in the classroom. As per Lave and Wenger's (1991) community of practice, mentioned previously, it allows learning conceptual and physical tools at the same proficiency used by a community, with the learner moving into that community and its culture. Now, second-year architecture students are on the periphery of the discipline; over time, they move into the core, accepting the rules and practices of the field, through instruction and experience. Therefore, an educator should keep the field in mind, while teaching a course on learning technology to architecture students, irrespective of whether they are potential future teachers or architects.

6.6 Descriptive category 6: Transferring and understanding knowledge

Six students valued learning technology for the transfer of knowledge and to improve understanding.

> In my opinion, educational technology is computer-assisted instruction that every teacher must use in teaching, in order to develop teaching skills and use it as a tool to transfer knowledge to students. (Cam)
> From watching animations and videos, we can understand the subject easier through the online stores, and it's more fun. (May)

> Computer games are another tool to transfer knowledge to students with fun and allow more understanding in the lesson. In addition, Computer Assisted Instruction (CAI) is a necessary tool to transfer knowledge to students. (Eva)

One student felt learning technology was for the transfer of knowledge; three acknowledged it for improving understanding of the subject matter, and two that it served both purposes. Referring to computer-assisted learning, students mentioned teaching for transferring knowledge and understanding, but these have distinctive theoretical underpinnings. A behavioral perspective underpins the transfer of knowledge from one individual to another, or from teachers to students, with the learner considered an empty vessel; teachers transfer knowledge from themselves to the learner. Learning theories for understanding were espoused by Vygotsky (1978) and Marton (1981): a component of a technology course should be dedicated to the link between learning theories and learning technology. Additionally, educators should use student comments on learning technology as an awareness framework for learning.

6.7 Students' experience and feeling with learning Technology in the Classroom

From Fig. 1, most of them expressed that the lesson integrated with technology was interesting and not boring (28%). The rest of them felt the lesson fun (11%), useful (11%), easy for them to understand the topic (11%), relaxed and less stressed (17%), convenient (11%) for them to apply the knowledge and they could pay more

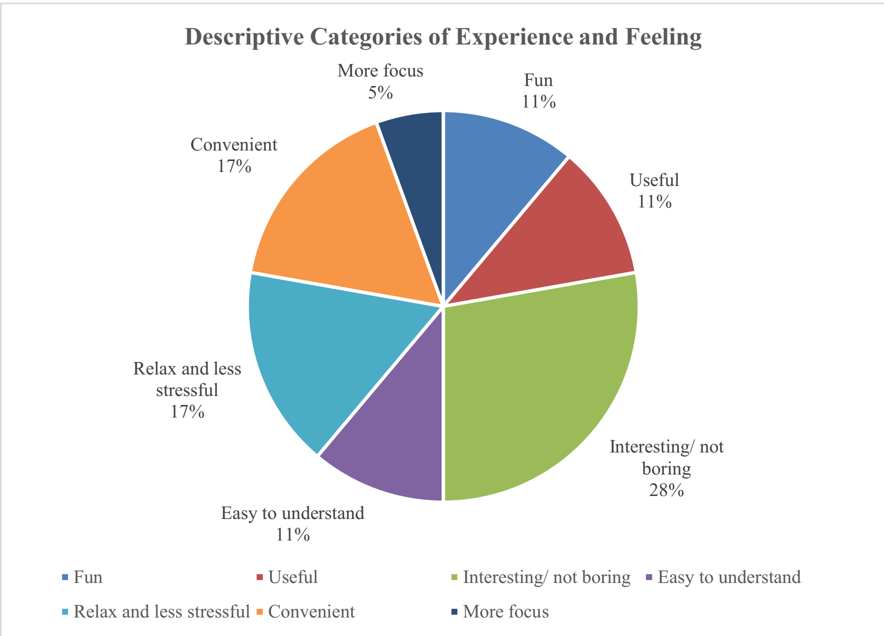

Fig. 1 Students' experience and feeling with learning technology in the classroom

attention in the lesson (5%). In other words, they had a positive experience and feeling with the lesson integrated with technology. Students were to be more interested in the classroom because the advancement of technology provides different learning chances and more interesting activities to make learning more fun. For example, based on their experience, their teachers used gamification techniques in the classroom such as Kahoot!. With the use of gamification technique, students feel more excited to involve and engage in the competition through online quizzes which provides sound effect and immediate feedback for students. This kind of activity is difficult to be designed through a traditional teaching and learning environment. Also, for students who are interested in the topic taught by teachers who used technology such as video, they can enhance their cognitive retention and retain more information. This is because they expressed that they felt relaxed and less stressed when teachers used video to deliver the lesson to them. This also enables them to understand the topic easily after having an immersive and engaging learning experience. In fact, technological development has unlocked the paths for teachers and learners to apply online resources in their learning and teaching (Jalaluddin 2016), enabling students to have a better learning experience in different learning environments.

6.8 Types of technology use perceived by students as future teachers

Table 2 shows the types of technology use perceived by students as future teachers.

The interview results showed that the architecture students had a high desire to become a teacher in the future. Thus, a question related to the type of technology tools that they will use in the future classroom was asked. This question can help them perceive how useful technology tools would be and inspire them to implement the tools in the classroom. Focusing on the future use of technology can be valuable and call their attention to widening the scope of learning technology use, mainly to meet the needs of architecture students.

The types of learning technology use as perceived by students are demonstrated in Table 2. This information will help inform the preference of technology tools they will that can be used for classroom teaching in the future. The technology tool that students perceived to use mostly in their future classroom was educational games. This choice was followed by video/movie, communication tools, and the internet such as GoogleMaps. Students explained the different purposes of using technology. Students favoured educational games because they believed that these entertain students, promote fun, and reduce stress while learning the subject matter. For example, Bicen and Kocakoyun (2018), Wang and Tahir (2020) and Kew (2021) confirmed Kahoot! is an effective tool to improve students' knowledge and academic results. Besides, video and movies were preferred choices for students highlighted various advantages of sharing knowledge in a video format. For instance, students reasoned that a video encourages students to participate in class activities, assists them to understand the topic easily, and catches their attention. Problem of students paying attention to in the classroom is common (Cicekci and Sadik 2019); thus, the video can be regarded as one of the defensible ways to solve this issue.

Table 2 Types of technology tools used by students in their future career as teacher

No.	Types of Technology Use	Purposes/reasons	n
1	Videos/ Movies	• encourage students to participate in-class activities. • share knowledge for better understanding. • get students' attention. • Promote to learn more. • make understanding easier. • are fun.	6
2	Educational Games	• entertain students in learning. • are for relaxation and entertainment. • reduce student stress in learning. • transfer knowledge to students with fun and allow promote more understanding of the lesson. • help students gain knowledge. • such as Kahoot! makes class interesting. • train students play games and gain knowledge at the same time. • are fun.	8
3	Communication tools	• such as Facebook helps communicate information with students. • use video call to ask and answer questions, • communicate with students easily. • help shy students to express their opinions. • allow students to express their opinions in class.	5
4	Internet (e.g., GoogleMaps, etc.)	• show people a virtual building. • show the students virtual locations before visiting the actual place. • help searches for information. • are used for distance learning. • assist submit and mark work online and reducing paper.	5
5	Electronic book	• allows reading online. • reason is not stated	2
6	PowerPoint Slides	• make a lesson more interesting and get students' attention. • make lesson not boring. • The reason is not stated. • make the lesson more interesting.	4
7	House Design Tools (e.g., AutoCAD)	• design houses. • teach students.	2
8	Virtual or Augmented Reality	• show people a virtual building.	1
9.	Hardware (e.g., projector, microphone, laptop, computer laboratory)	• print out a model. • use a projector to present information. • use a projector, a microphone, and a laptop for a future class. • use a computer laboratory to play educational games. Attracts students to learn because not everyone has a smartphone or laptop	4
10	Others (e.g., check attendance)	• check attendance and find out who has disappeared. • count the number of students in the class with a barcode.	2

7 Implications

7.1 Phenomenography as an assessment tool

Through interviews, architecture students individually made relational meanings about the use learning technology in the context of an educational technology course. For example, the student participant, Von, made relational meaning of the "content" of learning technology through his statement: "We can use technology to support distance education.". In a conversation on the same topic, each student may make one or more relational meanings; for example, Von said "So all students can learn, even though they live far away in the countryside. Everyone gets knowledge, and they are equal in learning." When a person makes one or more relational meanings, it is labelled as intra-variation within an individual. Relational meanings also vary among individuals - inter-variation. For example, about learning technology, Sam stated "I use AutoCAD and Sketch Up in the Design module…to design a house model." While Von expressed one relational meaning of learning technology, Sam stated another. These qualitatively different ways of thinking about the same phenomenon are inter-variation. Intra- and inter-variations were pooled to characterize the qualitatively different ways of experiencing or conceptualizing the phenomenon of learning technology. Different relational meanings constitute clusters or descriptive categories, that form the outcome space in which students move (Marton 1981). Student ways of thinking serve as curriculum frameworks.

7.2 Structural awareness as a curriculum framework

After exploring student conceptions in an educational technology course, educators need to help students become aware of them. Each category of description depicted in Table 1 provides educators with the content of a technology curriculum. This step suggests that educators use student awareness as a curriculum framework, contemplate how to integrate student awareness into the curriculum, and design and develop challenging lessons and activities. Founded on variation learning theory, learning technology use may enrich student understanding, and enhance instruction in the field of architecture. When educators value qualitatively different conceptions and develop them, students have the confidence and readiness to frame their thinking with learning theories: for example, to build knowledge through reflection and interactive discourse using virtual platforms. There is an increased likelihood for architecture students to undergo transformative experiences by becoming aware of their conceptions to learn expert knowledge, understanding, and skills. If so, architecture students will be able to translate this knowledge into becoming effective architecture teachers. Thus, this study gives technology educators an alternative way, the variation theory of learning, to contemplate redesigning the curriculum.

The learning technology curriculum an educator develops should reflect each category of description: learning online, searching for information and knowledge, defining social media connectivity, exploring a virtual place, designing a model house, and transferring knowledge and understanding. If the descriptive categories are used as curriculum frameworks, the course content will consist of activities strategically planned for students to experience online learning, that might reflect distance, blended, and independent learning, alongside face-to-face classroom learning. Within these contexts, a student is given experiences in searching for information and knowledge for projects, although we know that students nowadays will automatically do it on their own. Students experience social media connectivity, through an available virtual platform for community-building, to openly express views and exchange ideas on deliberately planned issues. The educator designs exploration activities so that students have meaningful experiences with the capabilities of Web-mapping tools. Likewise, students have opportunities to design model houses using technology and present not only computer but also physical models. This assignment can be a long-term project. Finally, any experience given to students, whether independent learning, searching for knowledge, social media connectivity, or designing a model house, should support defensible learning theories.

In a learning technology course, the teacher should explicitly link learning sciences and architecture activities, both in theory and practice, so that students become aware of the connections; any learning technology course should have a component on learning theories so that these are visible to students. Contemporary understanding of the nature of learning, with new principles, processes, and outcomes, gives educators opportunities to provide students with new educational designs, roles, and entities. Educators need to remember that learning, with and through technology, is no longer peripheral or supplementary, but a key part of the process (Guney and Geiger 2015).

Students should experience learning as a change from their perspectives to a deeper and more complex understanding of the phenomenon of content within a learning context (Marton and Tsui 2004). The learner should understand that a move between different perspectives shapes their thinking and understanding of the phenomenon. Students should also understand that their conceptions of a phenomenon are provisional and qualitative. Instead of neglecting learner ideas about learning technology use, students should have multiple opportunities and contexts to translate their knowledge to new experiences.

In this study, a student thought, independent learning means they completely owned the space, leaving the teacher out. This stance requires a shift in thinking. This change should be one of conceptual dispersion so that the learners add to their repertoire of knowledge. An attempt to dispel personal ideas, as traditional conceptual change theorists suggest (Duit and Treagust 2003), may not be useful in considering a social phenomenon, such as learning technology use. Students should become aware of the distinction between the two forms of independent learning (self-driven and teacher-driven).

The field of architecture is design-based, requiring independence, motivation, metacognition, and reflection. Only an educator can augment student characteristics by strategically using inquiry-oriented teaching (Paris and Paris 2001; Van Grinsven and Tillema 2006). A teacher as a coach (Van Grinsven and Tillema 2006), mentor (Malone and Smith 1996), or guide (Bishop 2006) may promote independent learning through a range of strategies, including teacher scaffolding; providing students with opportunities to self-monitor; offering models of behaviour; developing a language for learning, and providing feedback on homework (Black 2007). A project, such as designing a model house, is an inquiry activity, that should revolve around a key question, that is meaningful, worthwhile, and feasible. The strategies use the educators' understanding of how students think and learn, guiding them towards independence. The consequence of such a teaching approach generates positive outcomes, engaging students in learning tasks with increased motivation, metacognition, and reflection.

Moreover, this study also identified student preference for the use of technology tools in the future classroom. The majority of them showed their high interest and preference for the educational game followed by video/movie, communication tools, and the internet such as GoogleMaps. It is suggested that these tools can be continuously developed and designed so that the instructors can implement them in their teaching practice to meet the demands of students. In particular, the findings demonstrated that these students had a good and positive learning experience in the learning technology course. They felt that the lesson was fun, useful, interesting/not boring, easy for them to understand, relaxing and less stressful, convenient for them to use, and be more focused in the lesson.

8 Conclusions

Here, we used phenomenography as the methodological framework to analyse and group architecture students' conceptions of learning technology use into descriptive categories. There were six categories of description, and each had its values. The study implies the use of phenomenography as an assessment tool for structural awareness and curriculum framework. Moreover, students' experiences in the lessons integrated with technology were analysed. The potential tools that can be continuously implemented in the future class are demonstrated in this paper.

9 Limitations

One weakness of the study pertained to the individual interviews, in that not all authors could participate fully in the phenomnographic research because of language barrier. The second-year architecture students expressed themselves in Thai language (translated later); as only one of the authors was a native Thai speaker. It may have been that, during the interviews, contribution from the other author, including opportunities to ask reflexive questions built on the interviewees' answers, was more limited than they might have been in English.

10 Recommendations for further research

This study gave us an opportunity to explore students' "beginning" conceptions with intellectual empathy and care. We refer to this stage as the "romance". The extension of this stage can set the context for further research. Through the design and development of a lesson sequence, using the categories of description portrayed in Table 1, we can measure students' "developing" conceptions at various points over time. This is the "generalization" stage. We can also measure student "developed" conceptions at the end of the semester. This is the "precision" stage. The various stages are Whitehead's modes of learning or three stages of education (Allan 2013) and Thagard's (1992) period of learner development--beginning, developing, and developed.

An extension of this study would use the current architecture student relational meanings and values of learning technology as items in a survey. Once a representative sample of qualitative interviews is obtained, the next step, coupling existing data with quantitative data, would lead to a substantive conclusion.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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