Journal of Turkish Science Education, 2021, *18*(1), 32-53.
DOI no: 10.36681/tused.2021.51

Journal of Turkish Science Education
http://www.tused.org
© ISSN: 1304-6020

"Unless You Can Explain": Voices of Graduate Students and Their Professor Regarding the Importance of Science Communication Course

Nadi Suprapto[1], Chih-Hsiung Ku[2], Te-Sheng Chang[3]

[1]*Universitas Negeri Surabaya, Undergraduate Program of Physics Education, Surabaya, Indonesia; ORCID: 0000-0002-8990-7412*
[2]*National Dong Hwa University, Graduate Institute of Science Education, Hualien, Taiwan.*
[3]*National Dong Hwa University, Graduate Institute of Education, Hualien, Taiwan; ORCID: 0000-0003-3739-3015*

ABSTRACT
This study aimed to analyse the experiences of graduate students and their professor deal with science communication courses. Capturing the nature and the pedagogic experiences of the courses and describing the trend issues around them were the main focus of this study. By using a constructivist approach, eight graduate students and one Professor of science education program at a public university in the East of Taiwan were submitted participant qualitative interviews to discuss their learning experiences in the course. The findings revealed that first; science communication bridges the gap between people and science communities and includes interaction between various other longer-established academic domains. Second, it is about interpersonal and public communication among and by science professionals. Third, it emphasises the importance of communicative pedagogy: instructional design, media and technology, classroom management, interpersonal interaction, and assessment. Fourth, the trending issue around science communication can be reviewed from science content, nature of science, and social cognition theory. This study pinpoints the position of science, communication, and science communication as a package in which giving a linkage between scientists and science communicators as collective roles.

ARTICLE INFORMATION
Received:
13.06.2020
Accepted:
03.02.2021

KEYWORDS:
Graduate students,
Professor,
science
communication.

Introduction

A scientist has to master the concept of science itself and be able to communicate it. Therefore, the role of a scientist and science communicator is like two sides of a coin. It has created science communication which is a new branch of science and undoubtedly different from communication science in social sciences. The term "science communication" refers both to an interdisciplinary field of study and related fields of professional practices (Priest, 2010). Science communication as a multidisciplinary field encompasses communication studies, education, philosophy, sociology, political science, history, ethics, and science. The general understanding of the practice areas has evolved into including public understanding of science, scientific literacy, public outreach, public relations activities, public engagement with science and technology, and science edu-communication (Bowater & Yeoman, 2013; Knight, 2006; Priest, 2010; Wu, Truong, Lu, Tseng, & Chang, 2019). Though there is still on-going discussion regarding the definition of science communication, for this study, the term "science communication" is defined as the process of translating complex science into concepts and language that are engaging and understandable to non-science audiences such as art lovers, those in business fields, educators, government personnel, industry professionals, journalists, musicians, and politicians (Burns, O'Connor, & Stocklmayer, 2003; Mercer-Mapstone & Kuchel, 2017). Meanwhile, "communication is a very complex process which consists of many subunits and some of them are within the formal command of lexis and grammar, without taking into account the context" (Lakhvich, 2014: 592). This definition highlights the common denominator supporting most of the debates, for grounding the importance of "science communication".

There were many differences in understanding the essential meaning and the principles among science, communication, and science communication (Edmondston & Dawson, 2014). As mentioned before, a scientist and science communicator's role is like two sides of a coin. The responsibility of a scientist is not only to focus on mastering scientific concepts but also to communicate them. However, many people including scientists and science communicators have not a suitable description for the role of a scientist. This situation enables to address these two role positions and to explore the gap between scientist and science communicator through course experiences at the university level.

One popular approach to a science communication course at (post)graduate level is to ensure that science graduates are equipped with relevant and well-developed communication skills. There is a global agreement on the training of graduate science students that science communication is beneficial at both societal and individual levels (e.g., Besley & Tanner, 2011; Bray, France, & Gilbert, 2012; 35). The integration of rhetoric or communication courses into the existing study programs was also suggested by Aberšek and Aberšek (2010). The overview of learning outcomes as generic skills, such as communication skills in science education, is more common in higher education across the UK, the USA, Australia, and Taiwan (Jones, Yates, & Kelder, 2011). Nonetheless, Trench and Bucchi (2010) pointed out that science communication as a subject of teaching and research in higher education has a short history, and science communication has received insufficient attention. Thus, this study focuses on how graduate students and their professors experienced a science communication course. This examination of the learning experience includes three themes:

- The grasping of the nature of science communication
- The pedagogy of the course
- The resulting understanding of critical issues and debates around science communication

Shpancer (2004) stated that exploring classroom learning experiences is vital due to: (1) a classroom is idiosyncratic in its ability to provide direct access to both expert and group processes, rather than purely delivering content; (2) a classroom is sole in that it offers a safe, and the simultaneous sight of the mind of an expert; (3) in class, as in real life, an unexpected turn carries risks, but also an opportunity, enthusiasm, and pleasurable experiences; and (4) newest technology should be used in a classroom to assist classroom learning process, but not as an end in itself.

Background to the Problem

Some previous researchers indicated the importance of science communication as an integral part of science education (Aberšek & Aberšek, 2010; Bray et al., 2011; Lakhvich, 2014; Mercer-Mapstone & Kuchel, 2017; Mulder, Longnecker, & Davis, 2008; Sturloni, 2012; Wu et al., 2019). However, a few studies directly focus on the exploration of direct experience from the course. This study pinpoints the position of science, communication, and science communication as a package through giving a linkage between scientists and science communicators as collective roles.

Research Questions (RQs)

This study explores how graduate students and the professor at a public university in Eastern Taiwan experienced a science communication course and raises issues regarding:

1) How did graduate students who took the science communication course grasp the nature of science communication?

2) How did they experience the pedagogy of the course which emphasised the importance of communication?
3) On the other hand, how did the professor design the course and implement the pedagogy? How does he perceive students' learning?
4) To what extent did the course inform how graduate students and their professors perceive trend issues around science communication?

The below discussion takes four forms: (1) science communication, including communication between various other longer-established academic domains; (2) science communication is about interpersonal, and public communication among and by science professionals; (3) science communication emphasises the importance of communicative pedagogy. In this form, the discussion is about learning experiences regarding the design and instructional strategy, the use of media and technology, interpersonal interaction, classroom management, assessment process and feedback within graduate students and their professor; and (4) an exploration of the trend issues and key concepts around science communication.

Methods

Research Design

In this study, a constructivist approach is used (Charmaz, 2006) as one of the types of grounded theory designs. This approach stands between the more positivist and postmodern researchers (Creswell, 2012). The study focused on participants' meaning ascribed, which is more interested in participants' feelings, assumptions, views, beliefs, and values than in describing acts and gathering facts. By applying this approach, the emotion of participants is explained as they experienced a phenomenon and process. Predetermined categories are also captures such as those found in the coding process.

Data Collection

A qualitative interview method was engaged in this study (Yin, 2011). An in-depth interview focuses on describing how people experience some phenomenon, how they perceive it, describe it, and feel about it (Guest, Namey, & Mitchell, 2013). The researcher is allowed to be engaged in details and specifics of data, and therefore "get close to an individual's perspective" (Kayrooz & Trevitt, 2005). Interviews are often employed as a useful tool to understand people's experiences and to suggest useful explanations or interpretations of collecting qualitative data (Krathwohl, 1997; Yin, 2011). Therefore, face to face semi-structured interviews of individuals is appropriate for the research purpose of exploring the participants' perspective on their learning experiences in the course of science communication.

The study used an interview protocol developed by the first author. The researchers considered the validity and reliability of the list of questions through a focus group discussion between the team of researchers and other doctoral students as volunteers. This interview protocol contained eight open-ended questions for exploring the viable factors from classroom experiences on design and instructional strategy, the use of media and technology; interpersonal interaction; classroom management; assessment process and feedback; trend issue; and critical concepts around science communication. The essential documents (such as syllabus, course outline, and course references) were also collected to enrich the interview data. The interview process was a significant step to understand students' experiences and awareness of the essential issue around science communication. The interview process took approximately 1 hour for each interviewee, and it took place around the campus, near the library, or in the cafeteria. The interviews were audio-recorded and recordings were transcribed for analysis.

A convenience sample of eight students (4 males and 4 females) and one professor (the instructor of the course) from the science education programme were involved in this study. These students took the course titled "Social Cognition and Science Communication" from February to June 2015. In total, 11 students joined the class, including the first author. These students were all graduate students (master's and doctoral) and had studied from two to four semesters at a public university in Eastern Taiwan. The participants of this study are presented in Table 1. Out of the nine participants (graduate students and professor), there were seven Taiwanese and two Indonesian. The language of instruction was bilingual (Taiwanese and English). Since the first author was not fluent in Taiwanese, the interviews were conducted in English.

Consequently, many Taiwanese classmates were reluctant to participate due to anxieties of not being able to express themselves in English fully. Besides, most Taiwanese students in the class were in service teachers with tight schedules, and it was not convenient for them to arrange extra time for interviews. Due to both limitation of English and availability, eight students were able to participate when the research was conducted in the fall of 2015.

Table 1

A list of participant interview

Interviewee (Pseudonym)	Status	Age	Gender	Country of origin
P1: Chen	Ph.D. Student	35-40	Male	Taiwan
P2: Anggry	Masters Student	20-25	Female	Indonesia
P3: Nita	Masters Student	25-30	Female	Indonesia
P4: Wang	Ph.D. Student	45-50	Male	Taiwan
P5: Cheng	Professor	>50	Male	Taiwan
P6: Choi	Ph.D. Student	35-40	Male	Taiwan
P7: Sella	Ph.D. Student	30-35	Female	Taiwan
P8: Joy	Masters Student	20-25	Male	Taiwan
P9: Linda	Ph.D. Student	35-40	Female	Taiwan

The Researchers' Role

Researchers are a vital instrument in emerging participants' meanings (Creswell, 2007). The role of researchers in this study can be described as follows. The first author was part of the graduate students who participated in a science communication course while taking a science education in Taiwan. The second and the third authors contributed to validating the data after the coding process and manuscript writing. As a part of the class, the first author took an active role in classroom interaction and directly experienced the science communication course.

Ethical Considerations

Some significant ethical concerns guiding this qualitative research were: anonymity (pseudonym) (see Table 1), confidentiality, and informed consent. The authors obtained voluntary informed consent from participants by having them sign a written statement. It meant the participants understand the nature and the purpose of the research (Yin, 2011). Then, the researchers also considered confidentiality about participants' identities, including those appearing in audio- and videotapes and computer records. This research utilises data source triangulation from interview results and essential documents (such as syllabus, course outline, and course references).

Data Analysis

In this study, the types of data were personal narratives or conversations from the interview process and documents (Creswell, 2007; Holliday, 2007; Yin, 2011). The transcribed interviews were coded in two ways. First, the interviews were coded by the domains of the questions following the interview protocol such as terminology, instructional design, classroom management, social interaction, and relating issues about science communication. Second, more specific topics were separated to support different themes. Subsequently, the relevant information was chosen to enhance participant perceptions (see Figure 1 and Appendix). The documents (syllabus, course outline, and course references: see Appendix) were used to complement field interviews and conversations (Yin, 2011). These documents helped authors to explore the issues about the context and the situations inside the class.

Figure 1

The Process of Coding in Data Analysis

Example:		
The course is looking like science, technology and society (STS)	*Terminology*	*STS*
I think the main problem in classroom interaction is about language because some of us are international students and another is local student.	*Classroom interaction*	*Language problem, mixed-classroom*
The class gives us the opportunity to perform our knowledge by organizing classroom discussion, presentation chapter, going to the outside such as visiting watermelon shop for an easy science talking.	*Classroom management*	*Discussion, presentation, field trip*

All qualitative data from the analysis process are generated based on the themes found through the coding process, including:

1. Science communication bridges the gap between people and science communities and various other longer-established academic domains.
2. Science communication is about interpersonal and public communication among and by science professionals.
3. The importance of communicative pedagogy.
4. The trending issue around science communication can be reviewed from science content, nature of science, and social cognition theory.

All themes are discussed in the findings section.

Findings

Science Communication, Including Communication between Various Other Longer-Established Academic Domain

The science communication is course has been found to be based on awareness. Based on the syllabus, the course consisted of two themes as social cognition and science communication. Identifying and understanding social cognition becomes a prerequisite for implementing better science communication. Besides, an understanding of the philosophy of science, the nature of science, and other areas of study linked to science communication are fundamental in science communication learning. According to Professor Cheng:

I taught about some contents of social cognition and some contents of science communication. The key point of the course was how to construct social cognition and science communication. So, I have designed the content that might be 60% about social cognition, 30% about science communication, and the last 10% was about how to use the social cognition idea for studying of science communication (P5).

The course's intellectual design was clearly understood by the students. For example:

I still remember that learning science communication linked to the philosophy of the bird's beak, initiated by Thomas Kuhn of philosophical character [the structure of scientific revolution] (P2).

The idea of Professor [about] the history and philosophy of science was beneficial to open our mind before we overcame the special issue (P3).

In terms of learning framework, the role of science communication course was to communicate the knowledge and how to make interconnection among some phenomena around the world. In other words, the course was analogous to understanding Science, Technology, and Society (STS) and Socio-Scientific Issues (SSI). It can be confirmed that science communication includes communication between various other academic domains such as science itself, technology, and society. These arguments were also supported by Espejaa and Lagaróna (2015), who argued that SSI is an important concept, especially in the initial training of primary school teachers, pre-service teachers' conceptualisation of SSI, and appreciation of the value of teaching SSI. For teaching SSI issues, a belief system model might be considered (Kılınç, Kartal, Eroğlu, Demiral, Afacan, Polat, Guler, & Görgülü, 2013). This model included three belief pools as "content beliefs (CBs), core pedagogical beliefs (CPBs), and pedagogy of content beliefs (PCBs)" which were basic knowledge skills for pre-service teachers and teachers. Therefore, this concept was suitable for the course's participation because the majority of participants in this study are teachers.

The course teaching seeks to promote cross-disciplinary integration, civic engagement, and critical thinking. It helped to illuminate issues of professional responsibility and ethics. The course explored in rich and compelling ways difference it made to human societies that are collectively producers and users of science and technology, as the participants described:

The course looks like STS (Science, Technology and Society) which is a relatively new academic field (P1).

The rise of science communication or STS as a teaching field reflects a start point that specialization in today's research universities. It fully prepares future citizens to respond reflectively to the most important challenges of the world (P4).

Science Communication Is About Interpersonal and Public Communication among and By Science Professionals

Science communication is essentially both a matter of listening and a matter of practical expression. Each party must have some understanding of one another. Therefore, there is no doubt that communicating science is complicated (Stocklmayer, 2001). In science education, teachers need to transmit science knowledge to their students. One of the indicators of the success of transferring knowledge is the level of student understanding. Indeed, one of the participants gave her values to underline that science is not enough without communication skills. As Albert Einstein believed that "if you can't explain it simply, you don't understand it well enough" (Brainyquote, 2020) and "you do not really understand something unless you can explain it to your grandmother" (Goodreads, 2020). The following expression is the feeling of a participant:

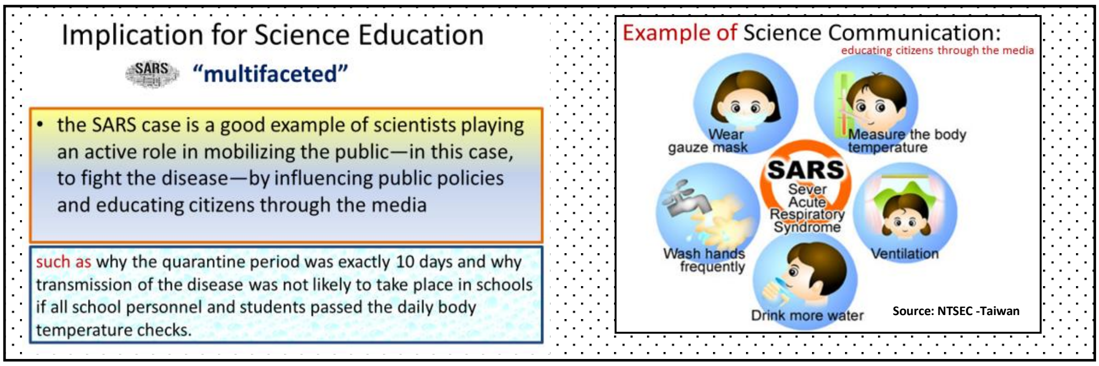
I feel motivated for the future. I want to become a science communicator. Indeed, if we already studied about science, we should communicate it better. Then, I also still remember the expression of Albert Einstein that "you do not really understand something unless you can explain it to your grandmother" (P3).

Then, regarding the position of graduate students as science communicators, their roles are essential. Figure 2 depicts an example created by a group of students while presenting their status as scientists to share the topic about "Severe Acute Respiratory Syndrome (SARS)". Some students argued that SARS reinforced their conception of science has an instrumental role to play in solving problems but that scientific knowledge does not automatically lead to problem resolution unless it can be translated into technological applications, effective public policies, and the actions of citizens. They referred to some science communication features provided by the National Taiwan Science Education Centre, NTSEC (Zhang, 2015).

I had an experience when presented the topic about "SARS". I positioned myself as a science communicator after presenting the nature of science dealt with this concept, then creating the shape of science communication to the citizen about it for educating citizens through the media (P2).

Figure 2

An Example of Science Communication Form Created By Graduate Students Regarding the Topic of SARS

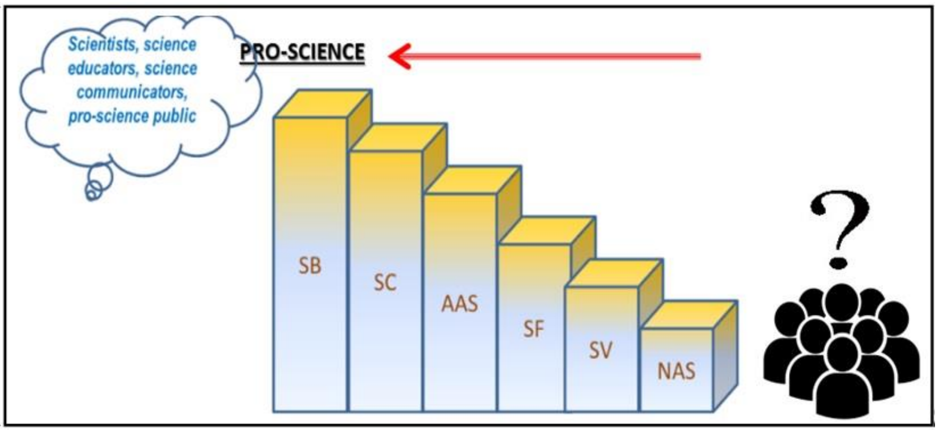


Note. Participant 3

Science communication is about interpersonal and public communication among and by science professionals. As a science educator and science communicator, each graduate student positioned himself or herself as a science believer (SB) (see Figure 3). In this position, science communication as a dimension is related to self-efficacy beliefs about science (Lin, Liang & Tsai, 2015; Suprapto, Chang & Ku, 2017). The majority of graduate students stood on the top level with three main characteristics: "science-literate", "pro-science", and "pro-scientism folk". These features appeared based on the Ogawa's scheme which generated six orientations of peoples' attitude towards science as follows (Aikenhead, 2001; Ogawa, 1998): "*(1)science-literate, pro-science, pro-scientism folk ("science believers"=SB);(2)science-literate, pro-science, anti-scientism folk ("science contextualists"= SC);(3)science-literate, anti-science, anti-scientism folk ("authentic anti-scientists"= AAS);(4) science-illiterate, pro-science, pro-scientism folk ("science fanatics"= SF);(5)science-illiterate, pro-science, anti-scientism folk ("science vigilantes"=SV); and (6)science-illiterate, anti-science, pro-scientism folk ("neo anti-scientists"=NAS)*". These orientations, which inferred by graduate students, confirmed that science communication is about interpersonal relations and science professionals.

Figure 3

The Six Orientations of People Regarding Their Role as Science Communicators



Note. Created by authors according to Ogawa (1998)

Science communication emphasises the importance of communicative pedagogy: Learning experiences viewed from instructional design, media and technology, interpersonal interaction, classroom management, and assessment

Instructional Design

Instructional design is the systematic development of instructional learning based on educational and psychological theory to ensure instruction quality. In general, the process consists of determining the learner's current needs, defining the end goal of instruction, and creating some intervention to assist in the learning process. In this course, the participants were Master and Ph.D. students. Therefore, the transformation process of knowledge was informed by pedagogically (process of teaching) and andragogically (adult learning). The content, of course, consisted of two parts as social cognition and science communication. As Professor Cheng explained:

> *The content of social cognition included social identity theory, self-esteem, social scheme, social representation, and social interaction. We concerned the authority of scientist, gender, and this was the hardest point of social cognition. And, the development of science communication included four periods which have different rationales (P5).*

As a knowledge, science communication emphasises how the citizens engage and are aware of the phenomena in daily life. In general, public people can understand what scientists do to monitor what scientists do that can help their lives become more straightforward. In the course, Professor Cheng transferred some knowledge of communication skills. Therefore, there can be said that the class design was planned convenient to the course. Additionally, in terms of instructional design, some graduate students explained that point as:

> *...It gave us more freedom as graduate students to deal with their creativity. Some examples can be said as comics' analysis, the relevance of paper analysis, movie analysis, the story of the nature of science, philosophy of science until many trend issues around science... (P1).*

I appreciated the class design. The class was well-organized, everything in our daily life was brought into the science communication course... the method for example by dividing the class into groups to make easy to adapt both local and international students (P9).

In terms of instructional design, the course addressed learning pedagogically and andragogically as commonly found at students' upper level such as university students (Fink, 2003). The classroom instruction also adopted Kaminski's (2015) classroom situation that considers general information on adult learners, an eclectic range of processes, and learning methods. Additionally, the classroom situation was also verified by Pitiporntapin's (2013) study that trained and transferred some communication knowledge to her participants to enhance communication skills.

Media and Technology

Regarding media and technology, the course used multiple modes of technology materials and tools such as internet, book references, comics, newspaper, magazine, PowerPoint presentation, LCD, journal papers, and DVD as participants clarified:

The most media usage was discussed in class between our students involved in the discussion, so I just used the media like PowerPoint (PPT), projector, some videos, some science materials, and the most part of the media were copied paper that our students must read (P5).

The course used research-based (for example, International Journal of Science Education (IJSE) part B) analysis, movie and information technology. It means the course, and outreach offers citizens of modern, high-tech societies, the resources with which to evaluate—analytically, aesthetically, and ethically (P7).

There were many information or book, but the language was very hard to understand. Therefore, I have preferred an article in the journal (P3).

The primary resource of the course was a textbook. The class used a book written by Augoustinos, Walker and Donaghue (2006). The teacher stated the textbook that was used for bridging the student knowledge. The book consisted of theoretical perspectives in social cognition, integration, application, and challenges. Considering the first part, the topics could be broken down into attitudes, social schemas, attributions, social identity, and social representations. Considering the second part, the issues expanded to bring the theory into practice, from social cognition to science communication.

Additionally, the role of information and communication technology (ICT), including internet use for communication media, was considered (Flanagin & Metzger, 2001; Huang, 2011). The use of social media also potentially promotes the science teachers' practices of SSI -- based teaching in a science classroom setting (Pitiporntapin & Lankford, 2015). Some participants gave some examples, while the class discussed a paper about "SARS" (Lee, 2008). The students explored the resources from the internet and conducted an online discussion to explore the roles and Nature of Science (NOS) regarding this case. Indeed, Ho (2007) also suggested the importance of electronic learning and other educational multimedia technology at the graduate level. Accordingly, the introduction of multimedia technologies into the curriculum will improve the quality of education. ICT can enhance students` learning. The study from Mork (2011) explored the learning environment in the science concept of "radioactivity" to provide insights into how the environment`s features may influence student learning. Some participants explained that as:

The use of ICT in the course helped us to grasp many open educational resources. Consequently, the discussion became clearer and more concise (P6).

ICT including the use of multi-sources on internet enriched the learning environment and stabilized the learning climate (P4).

Interpersonal Interaction

The class consisted of eleven students (five Ph.D. and six MA) with three were international students. The main challenge in the differentiated classroom was the difference in student need, student ability, and student interest, as Tomlinson (2001) proved that mixed-ability classrooms offer differentiated instruction for making a good sense for teachers and students. Logically, the local students wanted to have more proportion of the classroom in Chinese than English. In contrast, international students want to have more opportunities using English than Chinese. Though, for the teacher offering differentiated instruction first required a paradigm shift. In his course, the teacher used bilingual interaction.

I have a little trouble; sometimes I have to talk in mandarin to our local students as well as I must talk English to international students. So, I have memorized what I said for the local student then translate into English for the international students (P5).

Local students have highly interacted with the Professor because their language was similar. While teacher teaching us, local students faster to capture and to respond [the information] (P2).

Majid, Jelas, Azman, and Rahman (2010) also emphasised the significance of communication skills in teaching, knowledge advancement, the social aspect, and the importance of interpersonal relationships. However, the teacher hoped for all of the students to have good science communication experience in a language-barrier situation. Local students would improve their English while international students would better understand Chinese. Also, by the classroom interaction process, the teacher seemed this was the best way to motivate local students by adopting social cognitive theory to explain the phenomena in daily life.

I hoped that they had more interaction in the classroom. Maybe English was a barrier at that time (P5).

Classroom Management

In terms of classroom management, the classroom environment was designed in a "divergent thinking" approach. This kind of thinking is the essence of creative thinking (Cheng, 2010) and problem-solving (Raviv, 2012). The class focused on team-based, interpersonal, and individual and group hands-on activities. These activities allowed students to change their perspective, avoid unnecessary assumptions, and improvise using available resources, which aimed at encouraging divergent thinking (Raviv, 2012). Professor contributed enormously to a positive social climate in class, mainly through their communication with students (Özay, Kaya, & Sezek, 2004). For 18 weeks, the class activities consisted of lecturing, video analysis, paper analysis and critique, science-comic analysis, and outdoor activity. Both professors and the students enjoyed their course.

I constructed an excellent environment to help them entering the classroom and feeling happy to take what they thought, what they read, and what they wanted to understand (P5).

We must admit that the role of teacher for managing us was very appreciated, for instance, field trips, watching the movie, and many things (P3).

In addition, the course was managed by integrating knowledge from different views. As participants explicated:

The science communication course offered the ways of integrating knowledge in areas that were impossible to grasp through multi-disciplines. For examples, security studies, environmental studies, globalisation, the human sciences, biology and societies (P1).

The classroom allowed us to perform our knowledge by organising classroom discussion, presenting a chapter, going outside such as [visiting watermelon farms and shops] for easy science talking (P4).

Assessment

Assessment is a complete procedure of classroom evaluation. In the class, the teacher implemented "an instantaneous" assessment and feedback, as well as Socrates, did. The teacher provided more qualitative feedback on students' performance. Teacher evaluated the students' thinking and learning process rather than the students' knowledge (Çepni, Kara, & Cil, 2012; Lam, 2011). Generally, the assessment consisted of the assignments, midterm, and final exam. According to professor Cheng, however, the important thing was not about grade and test. Still, there was more emphasis on the learning experiences regarding science literacy, public understanding of science, and public awareness of science. Professor Cheng explained that:

I emphasised the general interaction and gave some home works in that semester, paid attention in the class and involved in our discussion and they [students] can interact with each other. For the feedback to students, I taught them like Socrates [Socratic discussion] with his students, with feedback instantaneously (P5).

Meanwhile, the response from the students regarding the assessment and feedback process was convergent. They agreed to the class situation and described that:

The important thing was not about the grade and assessment. Still, the more experience we can catch, the more information we can process and develop in our class, then we can implement those lessons in our daily activities (P1).

Talking about assessment, the teacher didn't explain more, but at the end of the course became clearer. Then, feedback of class either by the teacher or another student was very good,… really good (P8).

The sample quotations above allowed us to make some inferences. First, the professor implemented a quick assessment and quick feedback for better instruction. Second, the professor also provided more qualitative feedback on students' performance than just scoring as the quantitative model. These efforts in-lined with Tomlinson (2001), who suggested quick feedback, are essential to success in classroom interaction. Moreover, the teaching of communication skills has been a labour-intensive task because of the detailed feedback given to graduate students during their practice (Bahreini, Nadolski, & Westera, 2016).

The Trend Issues around Science Communication

In traditional science communication, scientists always stand in the centre lower part of scientific communication because they think people do not know the theory or science content. Therefore, they have to teach others and want other people to understand science. In contrast, Edmondston and Dawson (2014) argued that "the aim of public engagement is not only to communicate clearly, but also to improve the understanding, awareness, and science literacy of the public". Scientists require an understanding and an appreciation of civic science and its aims and an awareness of the repertoire of means available to achieve these aims. However, the modern concept of science communication allows people to be responsible for what scientists do/did. It means that scientists have a responsibility to make people understand, publish what they do/did. They did not emphasise general people teaching, just which people can monitor and understand the activities and the behaviour of scientists. This responsibility is called as public awareness.

Based on the participants' experience and feeling, there were many scientific issues from basic to complicated levels such as STEM (science-technology-engineering-mathematics) education, earthquake, climate change, weather forecasting, biotechnology, nanotechnology, the technology of robots, nuclear power, conservation, and some issues in daily life. These issues represented how science corresponds to other disciplines such as technology, education, social sciences, culture, politics, and economy. These issues were also confirmed by some previous researchers who also explored these essential concerns such as communicating climate (change) uncertainties (Chilvers et al., 2014; Rabinovich, Morton, & Birney, 2012; van Pelt et al., 2015), earthquake prediction (Papadopoulos, 2015), and environmental health risks (Friedman et al., 2015).

In terms of the ratio of science communication to the public, Stocklmayer (2001) summarised them into five headings: economic imperative, utilitarian argument, democratic, cultural, and social. Regarding the trend issue around science communication, the participants gave some details such as:

My answers [were] climate change, food biotechnology, and nanotechnology, which were useful for improving public engagement efforts on the part of scientists and their communities (P7).

… Not only case in Taiwan brought into class but also the phenomena that teacher knew or the trend issue in Taiwan (i.e., dust explosion, lantern festival). Indeed, from all around the world (such as World War I and II, endemic disease, SARS, H1N1) were explored in the class (P2).

Robots are a great tool for STEM education. My interest in engineering was first stimulated by Lego Mind Storms robotic kits when I was in the science club of junior high school. Therefore, I particularly enjoyed learning new things from hands-on experience (P8).

As well as the conceptual framework, how to communicate the knowledge and how to interconnect among some phenomena around us from a small case, [for example: tomato, Taiwan sweet potato] was discussed. We analysed why did some people include tomato as a fruit, but another categorises it as a vegetable? (P2).

The second issue was the nature of science (NOS). Science communication is about science content itself, not about *"the parrot-like talking"* and science gossip (Knight, 2006) *versus* rationality and authority. The parrot-like talking is happening when people are repeating everything that they heard very annoyingly for no reason and giving inaccurate information. However, the public people should have independent thinking and independent judgment regarding the issue of science. In other words, people should judge independently and believe about what does he/she thinks, not due to authority or what other people think regarding the question, "what is it or what is happening?". Professor Cheng thought that social cognition could make people more rational in dealing with science communication issues and stated that:

In terms of rationality, for instance, if our students after the class, they read newspapers, watch TV, or search news from the website, they can understand what they [reporters] said in the news more rationale and can understand if they believed some information relied on their authority, gender, or modern people. Might be this is a general science issue, people always believe authority [modern people said], but we have to know, we believe the information by the information itself, by authority or other (P5).

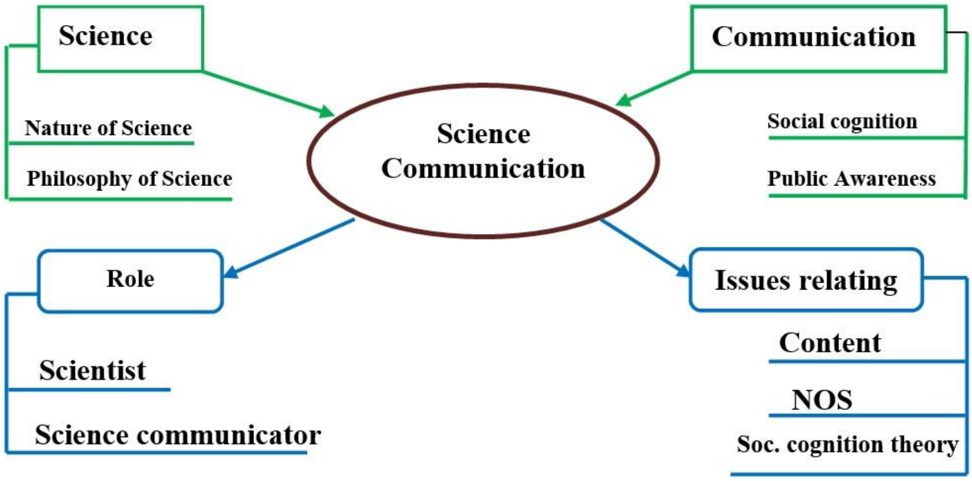
Science communication also tells us about the significance of social identification, social scheme, and social representation. These concepts belong to social cognitive theory. Professor Cheng (Participant 5) believed that many studies have concerns about social identification and science learning motivation. Therefore, according to his explanation, "some scholars think that high motivation of science should be maintained because people have high identification and become a member of the science community for science representation needs". Recently, Edmondston and Dawson (2014) also argued that an understanding of the legitimacy of the public voice in dialogue about science is vital. There was an international push to improve the effectiveness of scientists on how to communicate. It was acknowledged that communicating science to citizens is the responsibility of the qualified scientific community (Brownell, Price, & Steinman, 2013). Papadopoulos (2015) also underlined communicating earthquake prediction results publicly as a socially sensitive issue in Greece regarding social representation. The following voice represents the importance of science communication to the public regarding social presentation and the risks of science (mis)communication.

I remember some scientists in Italy, from their data collection, they knew maybe earthquake will be happening [L'Aquila earthquake tragedy], but they didn't announce to the public. So, their government decided that it was illegal. This issue will tell us science communication become more and more important in the future. Previously, scientists just studied about science, communication was not their responsibility. Then, regarding some scientific phenomena like the earthquake, weather forecast and nuclear power, science communication becomes very essential right now (P5).

The narration above is an example of science miscommunication. Professor Cheng reviewed the story of miscommunication by some scientists in Italy. As Sturloni (2012) reported, some scientists from the "National Commission for the Forecast and Prevention of Major Risks" of Italy provided inaccurate, incomplete, and contradictory information to L'Aquila's population. In fact, "a 6.3 magnitude earthquake struck the town of L'Aquila a week later on 6 April 2009 and killed 309 people" (Sturloni, 2012). Consequently, they were found guilty of multiple manslaughters and sentenced to six years in prison by the local court. This tragedy is how science communication is linked to science itself, social-humanity, technology, communication, and science in daily life. Becoming a scientist is not enough, however, the scientist's role in the duty of new invention and the responsibility to become a science communicator. Being science communicators, scientists should provide accurate, complete, and correct information to the public and they have a significant social responsibility. Scientists teach citizens to avoid "*parrot-like talking,* science gossip, and irrationality". Figure 4 illustrates the key concepts in science communication and the relationship between science and communication based on participant response voices. The diagram is constructed based on participants' voices in identifying science and communication as a discipline in establishing a science communication course. Thus, science education focuses on communication methods to reach the public (Aberšek & Aberšek, 2010; Wu et al., 2019).

Figure 4

The Key Concepts of Science Communication



Limitations, Discussion, and Conclusions

As indicated in the data collection part, this research used a convenience sample of eight students out of eleven students in total and one professor from the science education program. Additionally, out of the nine participants (graduate students and professor), there were seven Taiwanese, and two were Indonesian. Ideally, further research should involve multiple nationalities. The next constrain can be considered as the language since the language of instruction was bilingual (Taiwanese and English). Since the first author was not fluent in Taiwanese, then interviews were conducted in English. Therefore, subsequent studies should be considered in terms of language problems especially in the interviews.

The role of the science communication course is how to communicate scientific knowledge and interconnect it among phenomena all around the world. The core of the course also represents the relationship among science, technology, and society (STS) which have evolved to STEM (Sarı, Duygu, Şen, & Kırındı, 2020; Suprapto, 2016). and deals with socio-scientific issues (SSI). Since most graduate students were science believers (SBs) (Aikenhead, 2001; Ogawa, 1998), Professor Cheng used a belief system model (Kılınç et al., 2013) for teaching socio-scientific issues. It was also in lined with Serrano, Ibarra & Valenzuela (2020) who were applying sociocultural construction during teaching in the university. The critical learning experiences that can be inferred from the science communication course includes some dimensions: "instructional design, media and technology, classroom management, interpersonal interaction, and assessment and feedback". The course was designed through the depth and extensive knowledge as suggested by Kaminski (2015), including general information on adult learners, motivational factors, an eclectic range of processes and methods of learning, how to create a learning environment that increases the learning transfer, and numerous techniques for the determination of learning. Professor Cheng also optimised the trans-disciplinary course. As Mercer-Mapstone and Kuchel (2017) stated that science communication is a diverse and trans-disciplinary field with rapid evolution. Furthermore, Trench and Bucchi (2010) argued that science communication would benefit significantly if its relationships to related fields were articulated thoroughly.

Considering the trending issues around science communication can be viewed in three parts such as Nature of Science (NOS), science content and social cognition theory. From a science content perspective, the trending issue around science communication, including weather forecasting, earthquake, STEM education, climate change, biotechnology, nanotechnology, the technology of robots, nuclear power, conservation, and some issues in everyday life. In terms of the nature of science, the keywords are rationality and authority. For the contribution of social cognitive theory, the concept of social identification, social scheme, social representation, and social responsibility triggers a science communicator who explains the science content to the public accurately and comprehensively.

Based on the findings in this study, graduate students should adapt the science activities. They also provided judicious and sufficient explanations for changing the viewpoints and behaviour of people in the community. They had the opportunity to use more than one communication technology in their practice to promote public understanding of science (Pitiporntapin, 2013). Meanwhile, from the nature of science communication, graduate students as scientists can't just work in the laboratory, but they must conduct a balance between its discipline and how to communicate. Thus, the role of science and science communication are like twins. In the future, science communication will become more critical, especially for the possible issue, such as the weather and earthquakes.

Additionally, science communication bridges the gap between people and the science community. It is the challenge of science communication study. However, it is known that there is less researcher emphasis on the domain of science communication. Researchers are always concerned about informal science and have argued that "maybe science communication belongs to the informal science". It seems reasonable to believe that "every learner knows and can do a variety of things which have never been formally measured, evaluated, or certified by these formal learning systems" (Cheek, 2015). Lecturers should prioritise a science communication course, appropriate learning materials are need to be developed, and space is need to be created in a curriculum. Science always considers a rational discipline. Therefore, when science is considered from philosophy or social cognition, it can be found that science activity includes many social issues in the science community. From this rationale, especially for graduate students, it should be provided many materials and many issues for the future. Graduate students can learn either how to be a good scientist or a science communicator and avoid a science (mis)communication.

However, our findings in this study have some limitations. Firstly, participants may not be representative of all graduate students who studied in Taiwan. There may be differences in learning experiences regarding science communication courses in another campus. Generalisation cannot be made for learning experiences of other graduate students and professors in other Taiwan universities. Thus, generalisability of the findings to other students and other countries requires too much care. Future research may include a larger sample of graduate students from different universities, which may provide different academic experiences. Secondly, this study was limited to eight graduate students and one professor at a public university in Eastern Taiwan. So in future research, we could investigate the scientist's perspectives, the public speakers or communicator's perspectives, or the policy maker's views and awareness of the issues of science communication and public engagement of science. Suggestions to promote the role of scientists and science communicators can quickly be initiated through science communication courses. Other researchers may replicate our study to extend the discussion of science communication from different perspectives.

References

Abbott, S. E. (2013). *Learning experience*. http://edglossary.org/learning-experience/.

Aberšek, B., & Aberšek, M. K. (2010). Development of communication training paradigm for engineers. *Journal of Baltic Science Education, 9*(2), 99-108. http://oaji.net/articles/2014/987-1405171312.pdf

Aikenhead, G. S. (2001). Science communication with the public: A cross-cultural event. In S. M. Stocklmayer, M. M. Gore, & C. Bryant (Eds.), *Science communication in theory and practice*, (pp 23–45). Dordrecht, The Netherlands: Kluwer Academic Publishers. https://doi.org/10.1007/978-94-010-0620-0_2

Augoustinos, M., Walker, I., & Donaghue, N. (2006). *Social cognition: An integrated introduction (2nd ed.)*. London, England: Sage Publications Ltd.

Bahreini, K., Nadolski, R., & Westera, W. (2017). Communication skills training exploiting multimodal emotion recognition. *Interactive Learning Environments, 25*(8), 1065-1082. https://doi.org/10.1080/10494820.2016.1247286

Besley, J. C., & Tanner, A. H. (2011). What science communication scholars think about training scientists to communicate. *Science Communication, 33*(2), 239-263. https://doi.org/10.1177/1075547010386972

Bowater, L., & Yeoman, K. (2013). *Science communication: A practical guide for scientists*. Oxford, England: Wiley-Blackwell, John Wiley & Sons, Ltd.

Brainyquote. (2020). *Albert Einstein quotes*. https://www.brainyquote.com/quotes/albert_einstein_383803

Bray, B., France, B., & Gilbert, J. K. (2012). Identifying the essential elements of effective science communication: What do the experts say?. *International Journal of Science Education, Part B, 2*(1), 23–41. https://doi.org/10.1080/21548455.2011.611627

Brownell, S. E., Price, J. V., & Steinman, L. (2013). A writing-intensive course improves biology undergraduates' perception and confidence of their abilities to read scientific literature and communicate science. *Advances in Physiology Education, 37*(1), 70-79. https://doi.org/10.1152/advan.00138.2012

Burns, T. W., O'Connor, D. J., & Stocklmayer, S. M. (2003). Science communication: A contemporary definition. *Public Understanding of Science, 12*(2), 183-202. https://doi.org/10.1177/09636625030122004

Çepni, S., Kara, Y. & Cil, E. (2012). Middle school science and items of high school entrance examination: Examining the gap in Turkey. *Journal of Testing and Evaluation, 40*(3), 501-511.

Charmaz, K. (2006). *Constructing grounded theory*. London: Sage Publication Ltd.

Cheek, D. W. (2015). A panoramic view of the future of learning and the role of design(ers) in such experiences. In B. Hokanson, G. Clinton, & M. W. Tracey (Eds.), *The design of learning experience: Creating the future of educational technology*, (pp 4-37). Switzerland, AG: Springer International Publishing. https://doi.org/10.1007/978-3-319-16504-2_2

Cheng, V. M. Y. (2010). Teaching creative thinking in regular science lessons: Potentials and obstacles of three different approaches in an Asian context. *Asia-Pacific Forum on Science Learning and Teaching, 11*(1), Article 17.

Chilvers, J., Lorenzoni, I., Terry, G., Buckley, P., Pinnegar, J. K., & Gelcich, S. (2014). Public engagement with marine climate change issues: (Re)framings, understandings and responses. *Global Environmental Change, 29*, 165-179. https://doi.org/10.1016/j.gloenvcha.2014.09.006

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.).* Boston, MA: Pearson Education, Inc.

Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches (2nd ed.).* Thousand Oaks: Sage Publications.

Edmondston, J., & Dawson, V. (2014). Perspectives of science communication training held by lecturers of biotechnology and science communication. *International Journal of Science Education, Part B, 4*(2), 195-210. https://doi.org/10.1080/21548455.2013.793433

Espejaa, A. G., & Lagaróna, D. C. (2015). Socio-scientific issues (SSI) in initial training of primary school teachers: Pre-service teachers' conceptualization of SSI and appreciation of the value of teaching SSI. *Procedia - Social and Behavioral Sciences, 196*, 80-88. https://doi.org/10.1016/j.sbspro.2015.07.015

Fink, L. D. (2003). *Creating significant learning experiences: An integrated approach to designing college courses*. San Francisco, CA: Jossey-Bass.

Flanagin, A. J., & Metzger, M. J. (2001). Internet use in the contemporary media environment. *Human Communication Research, 27*(1), 153-181. https://doi.org/10.1111/j.1468-2958.2001.tb00779.x

Friedman, D. B., Toumey, C., Porter, D. E., Hong, J., Scott, G. I., & Lead, J. R. (2015). Communicating with the public about environmental health risks: A community-engaged approach to dialogue about metal speciation and toxicity. *Environment International, 74*, 9-12. https://doi.org/10.1016/j.envint.2014.09.015

Goodreads. (2020). *Albert Einstein quotes*. https://www.goodreads.com/quotes/271951-you-do-not-really-understand-something-unless-you-can-explain

Guest, G., Namey, E. E., & Mitchell, M. L. (2013). *Collecting qualitative data: A field manual for applied research*. Thousand Oaks, CA: Sage Publications Inc.

Ho, W.-C. (2007). Music students' perception of the use of multi-media technology at the graduate level in Hong Kong higher education. *Asia Pacific Education Review, 8*(1), 12-26. https://doi.org/10.1016/j.envint.2014.09.015

Holliday, A. (2007). *Doing and writing qualitative research (2nd ed.).* London, England: Sage Publications Ltd.

Huang, C.-J. (2011). The development of internet use for communication among undergraduate students: A multilevel analysis. *Asia Pacific Education Review, 12*(2), 215–226. https://doi.org/10.1007/s12564-010-9127-8

Jones, S., Yates, B., & Kelder, J. A. (2011). *Learning and teaching academic standards project: Science learning and teaching academic standards statement*. Retrieved from ABDC: http://www.abdc.edu.au/data/Accounting_LS/Accounting_Learning_Standards_-_February_2011.pdf.

Kaminski, K. (2015). Designing instruction through cognitive theory, problem solving, and learning transfer: An ethnographic case study. In B. Hokanson, G. Clinton, & M. W. Tracey (Eds.), *The design of learning experience: Creating the future of educational technology*, (pp 4–37). Switzerland, AG: Springer International Publishing. https://doi.org/10.1007/978-3-319-16504-2_3

Kayrooz, C., & Trevitt, C. (2005). *Research in organisations and communities: Tales from the real world*. Crows Nest, NSW: Allen & Unwin.

Kılınç, A., Kartal, T. Eroğlu, B., Demiral, Ü., Afacan, Ö., Polat, D., Guler, M. P. D., & Görgülü, Ö. (2013). Preservice Science Teachers' Efficacy Regarding a Socioscientific Issue: A Belief System Approach. *Research in Science Education, 43*, 2455-2475. https://doi.org/10.1007/s11165-013-9368-8

Knight, D. (2006). *Public understanding of science: A history of communicating scientific ideas*. New York, NY: Routledge.

Krathwohl, D. R. (1997). *Methods of educational and social science research: An integrated approach (2nd ed.)*. New York, NY: Longman.

Lakhvich, T. (2014). Science and communication: How to transfer knowledge?. *Journal of Baltic Science Education, 13*(5), 592–595. http://oaji.net/articles/2015/987-1450980809.pdf

Lam, F. (2011). *The Socratic method as an approach to learning and its benefits*. Carnegie Mellon University: Dietrich College Honors Theses. Retrieved from http://repository.cmu.edu/cgi/viewcontent.cgi?article=1126&context=hsshonors.

Lee, Y.-C. (2008). Exploring the roles and nature of science: A case study of severe acute respiratory syndrome. *International Journal of Science Education, 30*(4), 515-541. https://doi.org/10.1080/09500690701223368

Lin, T.-J, Liang, J.-C., & Tsai, C.-C. (2015). Identifying Taiwanese university students' physics learning profiles and their role in physics learning self-efficacy. *Research in Science Education, 45*(4), 605-624. https://doi.org/10.1007/s11165-014-9440-z

Madueño Serrano, M. L., Márquez Ibarra, L. & Manig Valenzuela, A. (2020). The engineering professors' teaching identity formation as university teachers: A process of sociocultural construction. *Journal of Turkish Science Education, 17*(4), 504-519. doi: 10.36681/tused.2020.41

Majid, N. A., Jelas, Z. M., Azman, N., & Rahman, S. (2010). Communication skills and work motivation amongst expert teachers. *Procedia Social and Behavioral Sciences, 7*(C), 565-567. https://doi.org/10.1016/j.sbspro.2010.10.075

Mercer-Mapstone, L., & Kuchel, L. (2017). Core skills for effective science communication: A teaching resource for undergraduate science education. *International Journal of Science Education, Part B, 7*(2), 181-201. https://doi.org/10.1080/21548455.2015.1113573

Mork, S. M. (2011). An interactive learning environment designed to increase the possibilities for learning and communicating about radioactivity. *Interactive Learning Environments, 19*(2), 163-177. https://doi.org/10.1080/10494820802651060

Mulder, H. A. J., Longnecker, N., & Davis, L. S. (2008). The state of science communication programs at universities around the world. *Science Communication, 30*(2), 277-287. https://doi.org/10.1177/1075547008324878

Ogawa, M. (1998). Under the noble flag of 'developing scientific and technological literacy'. *Studies in Science Education, 31*(1), 102-111. https://doi.org/10.1080/03057269808560116

Özay, E., Kaya, E., & Sezek, F. (2004). Application of a questionnaire to describe teacher communication behaviour and its association with students in science in Turkey. *Journal of Baltic Science Education, 2*(6), 15-21. http://oaji.net/articles/2016/987-1482420157.pdf

Papadopoulos, G. A. (2015). Communicating to the general public earthquake prediction information: Lessons learned in Greece. In M. Wyss, & S. Peppoloni (Eds.), *Geoethics: Ethical challenges and case studies in earth sciences,* (pp 223–239). Amsterdam, The Netherlands: Elsevier Inc. https://doi.org/10.1016/B978-0-12-799935-7.00019-8

Pitiporntapin, S. (2013). Thai pre-service science teachers' practice of science communication in communities. *Asia-Pacific Forum on Science Learning and Teaching, 14*(2), Article 1.

Pitiporntapin, S., & Lankford, D. M. (2015). Using social media to promote pre-service science teachers' practices of socio-scientific issue (SSI) - based teaching. *Asia-Pacific Forum on Science Learning and Teaching, 16*(2), Article 3.

Priest, S. H. (2010). Coming of age in the academy? The status of our emerging field. *Journal of Science Communication, 9*(3), C06. https://doi.org/10.22323/2.09030306

Rabinovich, A., Morton, T. A., & Birney, M. E. (2012). Communicating climate science: The role of perceived communicator's motives. *Journal of Environmental Psychology, 32*(1), 11–18. https://doi.org/10.1016/j.jenvp.2011.09.002

Raviv, D. (2012). *Encouraging divergent thinking. ASEE Annual Conference and Exposition*, Conference Proceedings. San Antonio, SA: American Society for Engineering Education.

Sarı, U., Duygu, E., Şen, Ö. F., & Kırındı, T. (2020). The Effect of STEM Education on Scientific Process Skills and STEM Awareness in Simulation Based Inquiry Learning Environment. *Journal of Turkish Science Education, 17*(3), 387-405. doi: 10.36681/tused.2020.34

Shpancer, N. (2004). What makes classroom learning a worthwhile experience?. Thought and Action, *The NEA Higher Education Journal (Winter), 23–35.* Retrieved from http://www.nea.org/assets/img/PubThoughtAndAction/TAA_04Win_03.pdf.

Stocklmayer, S. M. (2001). The background to effective science communication with the public. In S. M. Stocklmayer, M. M. Gore, & C. Bryant (Eds.), *Science communication in theory and practice*, (pp 23–45). Dordrecht, The Netherlands: Kluwer Academic Publishers. https://doi.org/10.1007/978-94-010-0620-0_1

Sturloni, G. (2012). A lesson from L'Aquila: The risks of science (mis)communication. *Journal of Science Communication, 11*(4), Editorial. https://doi.org/10.22323/2.11040501

Suprapto, N. (2016). Students' Attitudes towards STEM Education: Voices from Indonesian Junior High Schools. *Journal of Turkish Science Education, 13*(Special Issue), 75-87. doi: 10.12973/tused.10172a

Suprapto, N., Chang, T.-S., & Ku, C.-H. (2017). Conception of learning physics and self-efficacy among Indonesian university students. *Journal of Baltic Science Education, 16*(1), 7–19. http://oaji.net/articles/2017/987-1493049396.pdf

Tomlinson, C. A. (2001). *How to differentiate instruction in mixed-ability classrooms (2nd ed.)*. Alexandria, VA: ASCD.

Trench, B., & Bucchi, M. (2010). Science communication, an emerging discipline. *Journal of Science Communication, 9*(3), 1–5. https://doi.org/10.22323/2.09030303

van Pelt, S. C., Haasnoot, M., Arts, B., Ludwig, F., Swart, R., & Biesbroek, R. (2015). Communicating climate (change) uncertainties: Simulation games as boundary objects. *Environmental Science Policy, 45*, 41–52. https://doi.org/10.1016/j.envsci.2014.09.004

Wahlström, N. (2010). Learning to communicate or communicating to learn? A conceptual discussion on communication, meaning, and knowledge. *Journal of Curriculum Studies, 42*(4), 431–449. https://doi.org/10.1080/00220272.2010.495163

Wu, L. Y., Truong, N. M. Lu, H.-Y., Tseng, Y.-H., & Chang, C.-Y. (2019). Science-edu-communication: Trends reveal in 20 years of science communication research. *Journal of Baltic Science Education,18*(5), 793-805. https://doi.org/10.33225/jbse/19.18.793

Yin, R. K. (2011). *Qualitative research from start to finish*. New York, NY: The Guilford Press.

Zhang, Y.-T. (2015). *To know the SARS*. Taiwan: NTSEC. http://activity.ntsec.gov.tw/lifeworld/english/content/disease_cc12.html.

Journal of Turkish Science Education, 2021, *18*(1), 32-53.
DOI no: 10.36681/tused.2021.51

Appendix

Sample of transcripts from in-depth interview

Topics: Science Communication
Introduction:
Well...To be an honour for me can interview you. I very appreciate your help. Actually, I would like to know your experiences regarding the course social cognition and science communication you took last semester. This work as a practice and a part of my mini research from qualitative course. Now, I am starting to question:

Researcher	Participant (P1)	P2	P3	P(n)	First coding
What does the course look like? Please use your experiences	In my view, **the theories of social cognition will lead us to know is one thing...... to do is another. The course looks like STS or social technology science.** [Oh, you mean science, technology and society? Could you give me the example, based on your experience, please!] Yes, of course**. Science Technology Society (STS) studies is a relatively new academic field. Its roots lie in the inter-war period and continue into the start of the Cold War, when historians and sociologists of science, and scientists themselves, became interested in the relationship between scientific knowledge, technological systems, and society.**..... [thinking]...	**I still remember that learning science communication linked to the philosophy of the bird's beak, initiated by Thomas Kuhn of a philosophical character.** The learning...........It is also interesting. But, it reiterated in detail the concept that I do not quite remember very well. Overall, I can't assess the course. But, in terms of technology, classroom management, transfer of knowledge, I highly appreciated both from the classroom management side still need some improvement. Yeah... the lack of classroom management.	My experiences in general....Overall of this course....This is the first time for me joining the course of science communication. **I didn't take a similar course yet.** **I have very motivated in the future, I want to become a science communicator, indeed if we already studied science, we should communicate it better.** **Then, I also still remember from the Albert Einstein expression that "you do not really understand something unless you can explain it to your grandmother".** This expression makes an insight into my mind knows		Terminology, framework

Researcher	Participant (P1)	P2	P3	P(n)	First coding
			as well as I am a teacher. Thus, becoming a good scientist and a good communicator is very important. Taking for example, **students in senior high school feel boring if the subject matter taught without good communication in class. In other words, we still give students, many term or terminology, but the most important thing is how we communicate with them.**		
What are the trend issues around science communication based on your experiences either from course or daily live?	**My answer is climate change, food biotechnology, and nanotechnology, for improving public engagement efforts on the part of scientists and their organizations**. I emphasize the need for science communication initiatives. STEM issue is trend now, but how to do is still a challenge well. How to teach climate change, food biotechnology and nanotechnology become simple way? The answer is by modelling.	Relating to the previous explanation, **not only case in Taiwan brought to class but also the everything phenomena that teacher know or the trend issue in Taiwan (i.e. dust explosion), indeed from around the world (such as world war) were brought into class. I still remember when we watch movie about situation in Poland around WW II and following by discussion in class**. ….	There are many topics need to be communicated from the simple to complex. My hope is I can make everything make simple to communicate. Even though is it difficult for me. I still used physics language in teaching-learning activity but did not try to use daily language for closing students to the daily phenomena. **Actually, I feel need get information more either from friends or teachers the way to communicate science**		trend issues around science communication

Researcher	Participant (P1)	P2	P3	P(n)	First coding
			correctly clearly and informatively. For example, about fever case. Our thinking fever is must be cured, but in fact it is because of body reaction or reaction. The explanation is our body contaminated by a virus or bacteria then automatically the temperature of our body is increasing...		
....	....	....	....	....	....

Sample of Syllabus

[redacted]

教學計劃表 Syllabus

課程名稱(中文) Course Name in Chinese	社會認知與科學傳播			學年/學期 Academic Year/Semester	103/2
課程名稱(英文) Course Name in English	Social Cognition and Science Communication				
科目代碼 Course Code	SCE_70400	系級 Department & Year	博士	開課單位 Course-Offering Department	課程設計與潛能開發學系
修別 Type	選修 Elective	學分數/時間 Credit(s)/Hour(s)	3.0/3.0		
授課教師 Instructor	/古智雄				
先修課程 Prerequisite					

課程描述 Course Description

從社會社知觀點探討科學傳播議題,理論與實務並重.

課程目標 Course Objectives

1. 從社會認知理論剖析科學的傳播
2. 從社會文化脈胳瞭解科學傳播，並進而理解對科學學習的影響

圖示說明Illustration ：● 高度相關 Highly correlated ○中度相關 Moderately correlated

授 課 進 度 表 Teaching Schedule & Content

週次Week	內容 Subject/Topics	備註Remarks
1	社會認知與科學傳播(初探) Part I 社會認知理論	
2	A. 態度、社會基模 討論:「恐龍」科學與科幻影片對國小兒童認知影響之研究	
3	B 歸因、社會認同	
4	國慶假	
5	4. C. 社會基模與社會表徵	
6	5. D.歸因理論與社會表徵理論的整合	
7	6. E.刻板印象、偏見、與組間歸因	
8	7. Part II 科技傳播 vs. 傳播科技 科技與傳播	
9	期中考試週 Midterm Exam	
10	8. 閱聽人與新聞閱讀	
11	9. 科新新聞文本分析	
12	10. 議題設定理論之發展： 從領域遷徙、理論延展到理論整合	
13	11. 新聞傳播與媒體素養	
14	12. 科學新聞、科學普乃與非制式科學教育	
15	13. Part III 社會認知與科學傳播 討論: 從社會認知觀點探討醫師專業知識分享	
16	14. Communication sciences and disorders	
17	15. 討論: 氣象傳播中的媒體素養 16. 討論: 社會科學社群與自然科學社群的爭議: 索可事件 17. 討論:台灣七○年代科學普及與科學權威的意識型態 18 Poster interaction	
18	期末考試週 Final Exam	

教 學 策 略 Teaching Strategies

☑ 課堂講授 Lecture ☑ 分組討論Group Discussion ☑ 參觀實習 Field Trip

☐ 其他Miscellaneous:

學期成績計算及多元評量方式 Grading & Assessments

配分項目 Items	配分比例 Percentage	多元評量方式 Assessments							
		測驗會考	實作觀察	口頭發表	專題研究	創作展演	卷宗評量	證照檢定	其他
平時成績 General Performance	30%		✓	✓					
期中考成績 Midterm Exam	30%	✓	✓						
期末考成績 Final Exam	40%	✓			✓				
作業成績 Homework and/or Assignments									
其他 Miscellaneous (__________)									

評量方式補充說明 Grading & Assessments Supplemental instructions

教科書與參考書目（書名、作者、書局、代理商、說明） Textbook & Other References (Title, Author, Publisher, Agents, Remarks, etc.)

Augoustinos, M. & Walker, I. (1995). Social Cognition: An Integrated introduction. London: Sage.
Kunda, Z. (2000). The impact of motivation and affect on judgment. Social Cognition: making sense of people. (pp.211-262). Massachusetts Institute of Techonology.
Kunda, Z. (1987). Motivated inference: self-serving generation and evaluation of causal theories. Journal of Personality and Social Psychology, 53, 636-647.

課程教材網址（教師個人網址請列在本校內之網址） Teaching Aids & Teacher's Website (Personal website can be listed here.)

其他補充說明 (Supplemental instructions)