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- Ümmühan Ormancı (uormanci)
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At this stage, there are two aspects required from you:

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Dear Editor of TUSED,

The proofreading results from OREGDA is finished. Here, I am sending the manuscript accordingly.

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Dear Author, Okay, please make the necessary arrangements and send the final version. Sincerely

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The attachment is **the final version** of my manuscript.

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Dear Author,

Some suggestions were given on the article text as a result of the editorial review.

The article text is attached. By making these arrangements, you are expected to send

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Dear Editor of TUSED,

The attachment is **the revision version** of my manuscript that indicated with the **green** colour.

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“Unless You Can Explain”: Voices of Graduate Students and Their Professor Regarding The Importance of Science Communication Course

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 also describing the hot 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 submitted participant qualitative interviews to discuss their learning experiences in the courses. The findings revealed that first; science communication bridges the gap between people and science communities and includes communication between various other longer-established academic domains. Second, science communication 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 hot 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.

Keywords: graduate students, Professor, science communication

Introduction

The term “science communication” refers both to an interdisciplinary field of study and to a kind of 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 itself. The general understanding of the fields of practice has evolved to include 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 the purpose of this study, the term, “science communication,” is defined as the process of translating complex science into concepts and language that are

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engaging and understandable to non-scientific audiences such as art lovers, those in business fields, educators, government personnel, industry professionals, journalists, musicians, and politicians (Burns, O'Connor, & Stockmayer, 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). This definition highlights the common denominator undergirding most of the debates, for grounding the importance of "science communication".

Edmondston and Dawson (2014) indicated that there were many differences understanding regarding the essential meaning and the principles among science, communication, and science communication. In other words, many people have not a suitable description of the role of scientist, neither a scientist itself nor scientist plus science communicator. This situation allowed us as authors to address these two role positions and to explore these gaps 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 global agreement that the training of graduate science students in science communication is beneficial at both societal and individual levels" (e.g., Besley & Tanner, 2011; Bray, France, & Gilbert, 2011). 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 placed 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 the teaching of science communication has received scant attention. This study thus focuses on how graduate students and their professor 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, and the resulting understanding of critical issues and debates around science communication.

Shpancer (2004) stated that exploring classroom learning experiences is vital due to: (1) the classroom is idiosyncratic in its ability to provide direct access to both expert and group processes, rather than purely delivering content; (2) the classroom is sole in that it offers a safe,

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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) the newest technology should be used in the classroom to assist the 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, it was a few of study that directly focuses on the exploration of direct experience from a science communication course. 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.

Research Aim and Research Questions

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 this science communication course grasp the nature of science communication?
- 2) How did they experience the pedagogy of this 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 this course inform how graduate students and their professor perceive hot issues around science communication?

The discussion below takes four forms: (1) science communication, including communication between various other longer-established academic domain; (2) science communications 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

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management, assessment process and feedback within graduate students and their Professor; and (4) an exploration of the hot issues and key concepts around science communication.

Research Method

Research Design

In this study, we used a constructivist approach (Charmaz, 2006), one of the types of grounded theory designs. This approach stands between the more positivist and postmodern researcher (Creswell, 2012). We focused on the meaning ascribed by participants, which more interested in the feelings, assumptions, views, beliefs, and values of participants than in describing acts and gathering facts. In applying this approach, we explained the feelings of participants as they experienced a phenomenon and process. We also captured predetermined categories, 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 the details and specifics of the data, and therefore “get close to an individual’s perspective” (Kayrooz & Trevitt, 2005). Interviews are often employed as an effective tool to understand people’s experience 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. 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; hot issue; and key concepts around science communication. In addition, the important documents (such as syllabus, course outline, and course references) were also collected in order to enrich interview data. The interview process was the major step to understanding students’ experiences and awareness of the essential issue around science communication. The interviews were audio-recorded and transcribed for analysis.

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A convenience sample of eight students (4 males and 4 females), and one professor (the instructor of the course) from the program of science education 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 were Indonesian. The language of instruction was bilingual (Taiwanese and English). Since the first author as an interviewer was not fluently in Taiwanese, then interviews were conducted in English. Consequently, a large number of Taiwanese classmates were reluctant to participate for fear of not being able to express themselves in English fully. Besides, most of the Taiwanese students in that class were school teachers with tight schedules, and it was not convenient for them to arrange extra time for interviews. Due to both command 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)	Classification	Age	Gender	Country of origin
P1: Chen	Doctoral	35-40	Male	Taiwan
P2: Anggry	Master’s	20-25	Female	Indonesia
P3: Nita	Master’s	25-30	Female	Indonesia
P4: Wang	Doctoral	45-50	Male	Taiwan
P5: Cheng	Professor	>50	Male	Taiwan
P6: Choi	Doctoral	35-40	Male	Taiwan
P7: Sella	Doctoral	30-35	Female	Taiwan
P8: Joy	Master’s	20-25	Male	Taiwan
P9: Linda	Doctoral	35-40	Female	Taiwan

The Researchers's Role

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

Ethical Considerations

Some significant ethical concerns that 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, we also considered confidentiality about participants' identities, including those appearing in audio- and videotapes and computer records.

Data Analysis

The types of data in this study 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 some issues about science communication. Second, more specific topics were separated to support different themes. Subsequently, the relevant information was chosen to enhance the understanding of participant perceptions (see Figure 1 and Appendix). The documents (syllabus, course outline, and course references) 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.

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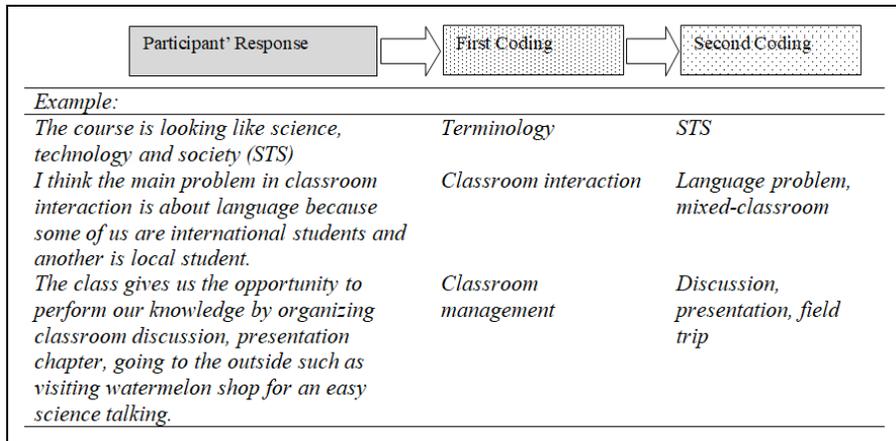


Figure 1. The process of coding in data analysis

Results and Discussion

1. Science communication, including communication between various other longer-established academic domain

Mercer-Mapstone and Kuchel (2017) stated that science communication is a diverse and trans-disciplinary field which has undergone rapid evolution. Furthermore, Trench and Bucchi (2010) argued that science communication would benefit significantly if its relationships to related fields were articulated thoroughly. We found that this course was grounded in this realisation. Based on the syllabus, the course consisted of two themes: social cognition and science communication. For implementing better science communication, identifying and understanding social cognition becomes a prerequisite. In addition, 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 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).

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

I still remembered that learning science communication linked to the philosophy of the bird's beak, initiated by Thomas Khun 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 how to communicate the knowledge and how to interconnect among some phenomena around the world. In other words, the course was analogous with understanding about Science, Technology and Society (STS) and Socio-Scientific Issues (SSI). We can confirm that science communication includes communication between various other academic domains: 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 (Kılınc, Kartal, Eroğlu, Demiral, Afacan, Polat, Guler, & Görgülü, 2013). This model included three belief pools: "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 participation of the course because the majority of them are teachers.

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

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

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

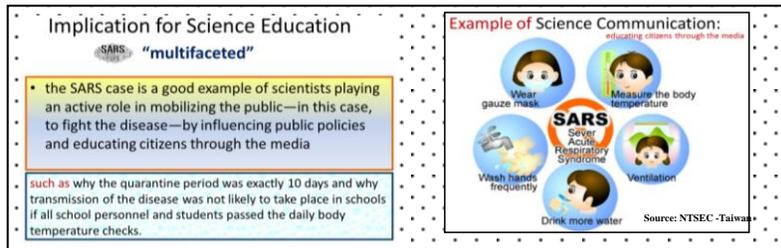
2. Science communication is about interpersonal and public communication among and by science professionals

Science communication is essentially both a matter of listening and a matter of effective expression. Each party must have some understanding one another. Therefore, there is no doubt that communicating science is difficult (Stocklmayer, 2001). In formal education, it is important for teachers to communicate science material to their student. One of the indicators of the success of transferring of knowledge is the level of student understanding. Indeed, one of the participants gave her values to underline that doing 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 one participant feeling,

I feel motivated in 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 from the Albert Einstein expression 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 very essential. Figure 2 depicts an example created by a group of students while presenting their position as scientists to share the topic about ‘Severe Acute Respiratory Syndrome’ (SARS). Some students argued that “SARS reinforced their conception that 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 National Taiwan Science Education Centre, NTSEC (Zhang, 2015). The completed information is available online at “http://activity.ntsec.gov.tw/lifeworld/english/disease_c12.html”.

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).



(Source: Participant 3)

Figure 2 An example of science communication form created by graduate students regarding the topic of SARS

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; Suprpto, 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 who 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 relation as well as science professionals.

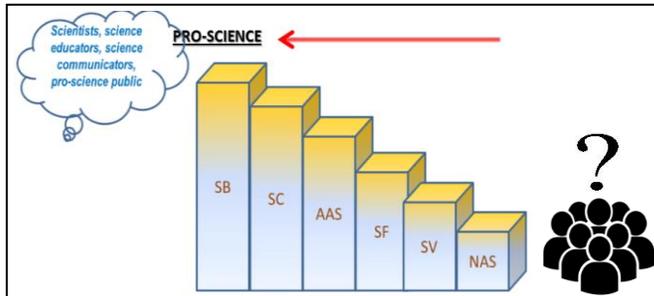


Figure 3 The six orientations of people regarding their role as science communicators (created by authors according to Ogawa (1998))

3. 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 the quality of instruction. In general, the process consists of determining the current needs of the learner, defining the end goal of instruction, and creating some intervention to assist in the learning process. In this course, the participants were Master and PhD 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: 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 of social cognition. And, the development of science communication included four periods, which have different rationales (P5).

Science communication as a knowledge, emphasises how the citizens engage and aware of the phenomena in daily life. For the general public, they can understand what scientist do, so they can monitor what scientist do that can help their lives become easier. In the course, Professor Cheng transferred some knowledge of communication skills. Therefore, the class

design was planned very well. Additionally, in terms of instructional design, some graduate students explained,

...It gave us more freely as graduate students deal with their creativity. Some examples: comics' analysis, the relevance of paper analysis, movie analysis, the story of the nature of science, philosophy of science until many hot 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 common found at upper level of students (Fink, 2003). The classroom instruction also adopted the classroom situation of Kaminski (2015) that consider general information on adult learners, an eclectic range of processes, and methods of learning. Additionally, the classroom situation also verified Pitiporntapin's (2013) study that trained and transferred some knowledge of communication to her participants in order to enhance communication skills.

Media and technology

Regarding media and technology, the course used multiple modes of technology, such as materials and tools, internet, book references, comics, newspaper, magazine, power point presentation, LCD, journal papers, and science' 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 (take for example, 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 was used for bridging the student knowledge. The book consisted of two parts: theoretical perspectives in social cognition and integration, application, and challenges. Turning to the first part, the topics could be broken down into attitudes, social schemas, attributions, social identity, and social representations. Considering the second part, the topics expanded to how to bring the theory into practice, from social cognition to science communication.

Additionally, the role of 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 (Pitipornatapin & 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 in graduate level. Accordingly, the introduction of multimedia technologies into the curriculum will improve the quality of education. ICT has a possibility to enhance students' learning. The study from Mork (2011) explored the learning environment in science concept: 'radioactivity' in order to provide insights into how features of the environment may influence student learning. Some participants explained,

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

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

Interpersonal interaction

In total, the class consisted of eleven students (five PhD and six MA), three of them were international students. In the differentiated classroom, the main challenge was about 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, as well as 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

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English than Chinese. For the teacher, though, 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 student (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 significance of interpersonal relationships. However, the teacher hoped for all of the students to have a good experience in science communication in a language-barrier situation. Local students would improve their English, while international students would better understand Chinese. In addition, by classroom interaction process teacher seemed this was the best way to motivate local students by adoption social cognitive theory to explain the phenomena in daily life.

I hoped 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 point of view, avoid unnecessary assumptions, and improvised using available resources, which aimed at encouraging divergent thinking (Raviv, 2012). Professor contributed enormously to a positive social climate at class, particularly 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 Professor and the students really 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. Teachers evaluated the students’ process of thinking and learning rather than the students’ knowledge (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, but there was more emphasis on the learning experiences regarding science literacy, public understanding of science, and public awareness of science. Professor Cheng explained,

I emphasised the general interaction and gave some homework’s 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,

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 an instantaneous assessment and quick feedback for better instruction. Second, the professor also provided more qualitative feedback on students' performance rather than just scoring as the quantitative model. These efforts in-lined with Tomlinson (2001) who suggested quick feedback is one important key to success in classroom interaction. Moreover, the teaching of communication skills has been a labour-intensive task because of the exhaustive feedback that should be given to graduate students during their practice (Bahreini, Nadolski, & Westera, 2016).

4. The hot 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 teaching people, just which people can monitor and understand the activities and the behaviour of scientists. This responsibility is called public awareness.

Based on the participants' experience and feeling, there were many scientific issues from the 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: technology, education, social, 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, Lorenzoni, ..., & Gelcich, 2014; Rabinovich, Morton, & Birney, 2012; van Pelt, Haasnoot, ..., & Biesbroek, 2015), earthquake prediction (Papadopoulos, 2015), and environmental health risks (Friedman, Toumey, ..., & Lead, 2015).

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

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 phenomena that teacher knew or the hot issue in Taiwan (i.e. Dust explosion, Lantern festival), indeed, from around the world (such as World War I and II, endemic disease, SARS, H1N1) were explored into 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 devote to the vegetable? (P2).

The second issue was the nature of science (NOS), in which science communication is not only about science content itself, but also considers 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 they heard very annoyingly for no reason and giving inaccurate information. However, the general public 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?, What is happening?”. Professor Cheng, though that social cognition could let people more rational in dealing with science communication issues.

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 motivation of science learning. Therefore, according to his explanation, ‘some scholars think that high motivation of science should be maintained because people have high identification, then they 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 how to communicate. It was acknowledged that the role of communicating science to citizens is the responsibility of the qualified scientific community (Brownell, Price, & Steinman, 2013). In terms of social representation, Papadopoulos (2015) also underlined communicating publicly earthquake prediction results as a socially sensitive issue in Greece. The following voice represents the importance of science communication to the public regarding the social representation 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 the example of science miscommunication. Professor Cheng reviewed the story of miscommunication by some scientists in Italy. As reported by Sturloni

(2012), some scientists from the “National Commission for the Forecast and Prevention of Major Risks”, of Italy provided inaccurate, incomplete, and contradictory information to the population in L’Aquila. 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. The lesson from 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 role of the scientist in the duty of new invention as well as the responsibility to become a science communicator. Being science communicators, scientists should provide accurate, complete, and correct information to the public and they have an important 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 the voices of participant response. It is clear that science education is oriented in focusing on communication methods to reach the public (Aberšek & Aberšek, 2010; Wu et al., 2019).

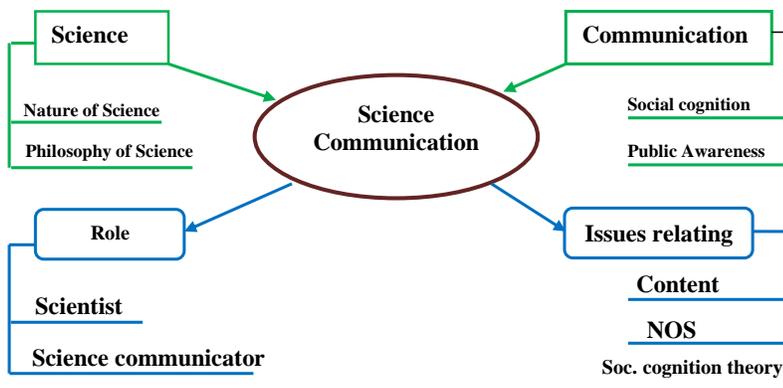


Figure 4 The key concepts of science communication

Limitations

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 program of science education.

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 language - the language of instruction was bilingual (Taiwanese and English). Since the first author as an interviewer was not fluently in Taiwanese, then interviews were conducted in English. Therefore, subsequent studies should consider language problems in their interviews.

Conclusions and Implications

The role of science communication course is how to communicate scientific knowledge and to interconnect it among phenomena around the world. The core of the course also represents the relationship among science, technology, and society (STS) and deals with socio-scientific issues (SSI). Since the 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. The critical learning experiences can be arrested 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 methods for determining of learning.

Considering the hot issues around science communication can be viewed from three parts: Nature of Science (NOS), science content, and social cognition theory. For science content perspective, the hot 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 science communicator 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 opportunities to use more than one communication technique in their practice to promote public understanding of science (Pitipornatapin, 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 important, especially for the possible issue, such as the weather and earthquakes. Additionally, science communication bridges the gap between people and the science community. This is the challenge of science communication study. However, we know that there is less researcher emphasis on the domain of science communication. Researchers always have concerned about the issue of 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 would have to prioritise science communication course, appropriate learning materials will need to be developed and space will need to be created in a curriculum. Science always considers as a rational discipline, therefore when we understand science from philosophy or social cognition, we can find science activity include many social issues in the science community. Then, from this rationale, especially for graduate students, it should be provided many materials and many issues for the future. Graduate students have the possibility to 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 other graduate students' and professor' learning experiences in other Taiwan universities. Thus, generalisability of the findings to other students and other countries is cautioned. Future research may include a larger sample of graduate students from different universities, which may provide different perspectives of academic experiences. Secondly, this study was limited to four 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 and the policy maker's perspectives and their awareness

of the issues of science communication and public engagement of science. Suggestions to promote the role of scientists, as well as science communicators can easily be initiated through science communication courses. Other researchers may replicate our study to extend the discussion of science communication from different perspectives.

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Appendix

SAMPLE OF TRANSCRIPTS FROM IN-DEPTH INTERVIEW

Topics: Science Communication

Introduction:

Well...To be an honor 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 the 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 Studies (STS) 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	I still remember that learning science communication linked to the philosophy of the bird's beak, initiated by Thomas Khun 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	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 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, framework

RESEARCHER	PARTICIPANT (P1)	P2	P3	P(n)	First coding
	of science, and scientists themselves, became interested in the relationship between scientific knowledge, technological systems, and society..... [thinking]...	of knowledge, I highly appreciated both from the classroom management side still need some improvement. Yeah... the lack of classroom management.	terminology, but the most important thing is how we communicate with them.	..	
What are the hot 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 hot 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. Modelling is my research area, our lab focus on modelling courses also build bridges between disciplines that do not ordinarily meet	Relating to the previous explanation, not only case in Taiwan brought to class but also the everything phenomena that teacher know or the hot 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. So, I think the learning process is very interesting and	Need more another journal paper. 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 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. We should give simple communication to our students or public about this case. So the approach to make them understand is the term of “ temperature”.		hot issues around science communication

RESEARCHER	PARTICIPANT (P1)	P2	P3	P(n)	First coding
	each other in the undergraduate curriculum, such as sociology and science, law and science, anthropology and technology, environmental science and political theory, or technology and philosophy....	suitable for graduate students. em. em the philosophy of science, social scheme also. The most topic that I was remember it.		..	
.....

Reviewer Suggestions/Critics	Author Answer
Reviewer A	
Comments in manuscripts	I have revised it. I indicated with the blue color
<p>It is interesting in terms of the point to be made in the research. It seems that it has been designed with the appropriate research method.</p> <p>However, there are places that need to be arranged in the research.</p>	<p>Thank you.</p> <p>I follow the suggestion.</p>
<p>Introduction: There are some meaning gaps between paragraphs. There must be transitions of meaning between paragraphs. Paragraph editing should be arranged according to the subject going from general to specific.</p>	<p>I have revised some parts of the introduction. The inserted sentences or paragraph is indicated with the blue color. For example, in paragraph 1: 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 a new branch of science, namely science communication, which is undoubtedly different from communication science in social sciences. The term "science communication" refers both....</p>
<p>It is also given in the first two paragraphs for the purpose and importance of the research.</p>	<p>I put this information in part of background to the problem: ...However, a few studies directly focus on the exploration of direct experience from a science communication course. 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.</p>
<p>The aim of the research should be expressed in a few sentences.</p>	<p>Now the RQ consisted of 4 points</p>
<p>The conclusions and discussions should be made after presenting the findings or results obtained from the research . After this part is rearranged, it can be scientifically reviewed.</p>	<p>Since this is a qualitative research, so I argued that the triangulation should represent the integration between findings and discussion together. However, I added and put some theories to support my findings and I have also organized part of Limitations,</p>

	Discussion, and Conclusions
There are discussions and inferences on the results that cannot be obtained from the research findings. These parts should be edited.	As I mentioned before, I organized the discussions based on the main themes as the findings: <p>The findings of the research are generated based on the themes found through the coding process, including:</p> <ol style="list-style-type: none"> 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
The findings and discussion part of the research has been kept long. This part should be shortened accordingly.	I have already reduced the number of sentences and paragraph
Reviewer B	
The paper has some merits but requires following reorganization for further review processes:	Thank you
You discuss your findings with the relevant literature in 'Results and Discussion' section.	Yes, I added some literatures to support my findings I have organized part of Limitations, Discussion, and Conclusions
Such preference limited the introduction section. I suggest you to produce a strong theoretical or literature review section in the introduction first and then discuss all of the quotations of the introduction in the discussion section. This reorganization will better inform your research questions and other sections.	I have put some addition sentences with indicated with the blue color in the revised version.

“Unless You Can Explain”: Voices of Graduate Students and Their Professor Regarding The Importance of Science Communication Course

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 submitted participant qualitative interviews to discuss their learning experiences in the courses. The findings revealed that first; science communication bridges the gap between people and science communities and includes communication between various other longer-established academic domains. Second, science communication 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.

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 a new branch of science, namely science communication, which is 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 areas of practice has evolved to include 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-scientific 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). This definition highlights the common denominator undergirding 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 obligation of a scientist is not only to focus on mastering scientific concepts but also to communicate them. However, many people have not a suitable description of a scientist's role, neither a scientist itself nor a scientist plus science communicator. This situation allowed us as authors to address these two role positions and to explore these gaps 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 that the training of graduate science students in science communication is beneficial at both societal and individual levels” (e.g., Besley & Tanner, 2011; Bray, France, & Gilbert, 2011). 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 scant attention. This study thus 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) the classroom is idiosyncratic in its ability to provide direct access to both expert and group processes, rather than purely delivering content; (2) the 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) the newest technology should be used in the classroom to assist the 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 a science communication course. 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.

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 this science communication course grasp the nature of science communication?
- 2) How did they experience the pedagogy of this 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 this course inform how graduate students and their professors perceive trend issues around science communication?

The discussion below 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.

Research Method

Research Design

In this study, we used a constructivist approach (Charmaz, 2006), one of the types of grounded theory designs. This approach stands between the more positivist and postmodern researchers (Creswell, 2012). We focused on participants' meaning ascribed, which is more interested in participants' feelings, assumptions, views, beliefs, and values than in describing acts and gathering facts. In applying this approach, we explained the emotions of participants as they experienced a phenomenon and process. We also captured predetermined categories, 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 the details and specifics of the 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 interview data. The interview process was a significant step to understanding students' experiences and awareness of the essential issue around science communication. The interview process took approximately 1 hour, and it took place around the campus, near the library, and in the cafeteria. The interviews were audio-recorded and 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 were Indonesian. The language of instruction was bilingual (Taiwanese and English). Since the first author was not fluent in Taiwanese, then interviews were conducted in English.

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

Table 1. A list of participant interview

Interviewee (Pseudonym)	Classification	Age	Gender	Country of origin
P1: Chen	Doctoral	35-40	Male	Taiwan
P2: Anggry	Master's	20-25	Female	Indonesia
P3: Nita	Master's	25-30	Female	Indonesia

P4: Wang	Doctoral	45-50	Male	Taiwan
P5: Cheng	Professor	>50	Male	Taiwan
P6: Choi	Doctoral	35-40	Male	Taiwan
P7: Sella	Doctoral	30-35	Female	Taiwan
P8: Joy	Master's	20-25	Male	Taiwan
P9: Linda	Doctoral	35-40	Female	Taiwan

The Researchers's 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 graduate students who participated in a science communication course while taking a science education in Taiwan. The second and third authors contributed to validating the data after the coding process and manuscript writing. As 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, we also considered confidentiality about participants' identities, including those appearing in audio- and videotapes and computer records.

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 some 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) 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.

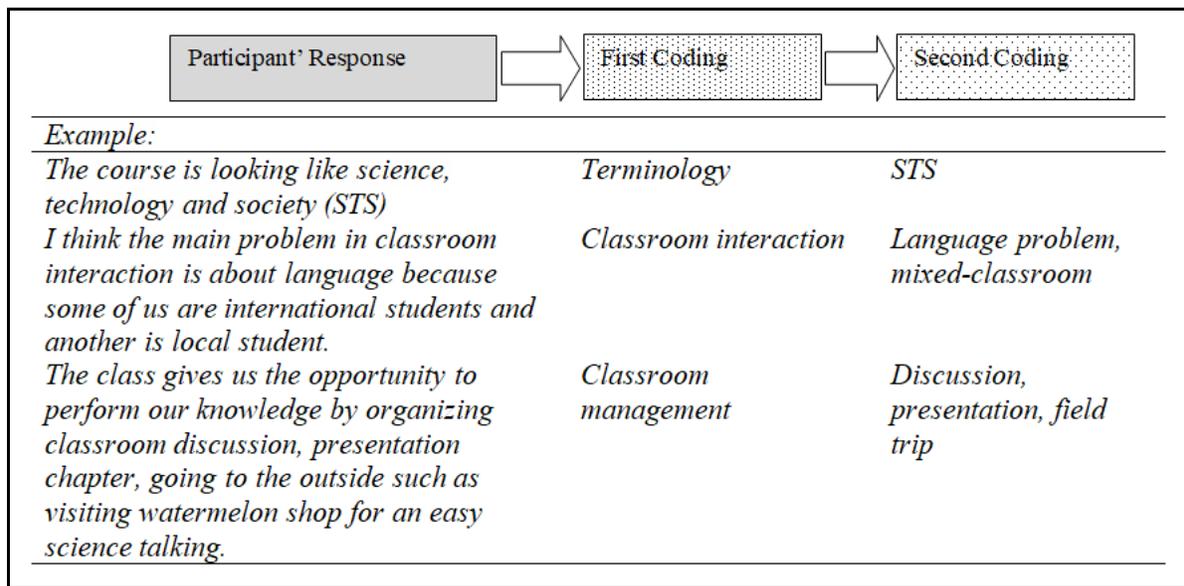


Figure 1. *The process of coding in data analysis*

Findings

The findings of the research 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 as follows.

1. Science communication, including communication between various other longer-established academic domain

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. We found that this course was grounded in this realisation. Based on the syllabus, the course consisted of two themes: social cognition and science communication. For implementing better science communication, identifying and understanding social cognition becomes a prerequisite. 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 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 felt by the students. For example:

I still remembered that learning science communication linked to the philosophy of the bird's beak, initiated by Thomas Khun 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 interconnect 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). We can confirm that science communication includes communication between various other academic domains: 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: "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 what difference it made to human societies that we, collectively, were being producers and users of science and technology as participants defined:

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

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

2. Science communication is about interpersonal and public communication among and by science professionals

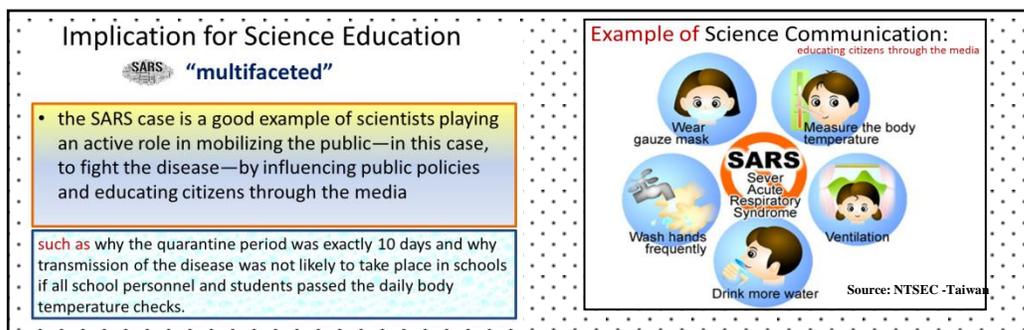
Science communication is essentially both a matter of listening and a matter of practical expression. Each party must have some understanding of one another. Therefore, there is no doubt that communicating science is complicated (Stocklmayer, 2001). In science education, teachers need to transmit science material 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 one participant feeling,

I feel motivated in 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 from the Albert Einstein expression 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 that 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). The completed information is available online at “http://activity.ntsec.gov.tw/lifeworld/english/disease_c12.html”.

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).



(Source: Participant 3)

Figure 2 An example of science communication form created by graduate students regarding the topic of SARS

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; Suprpto, 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.

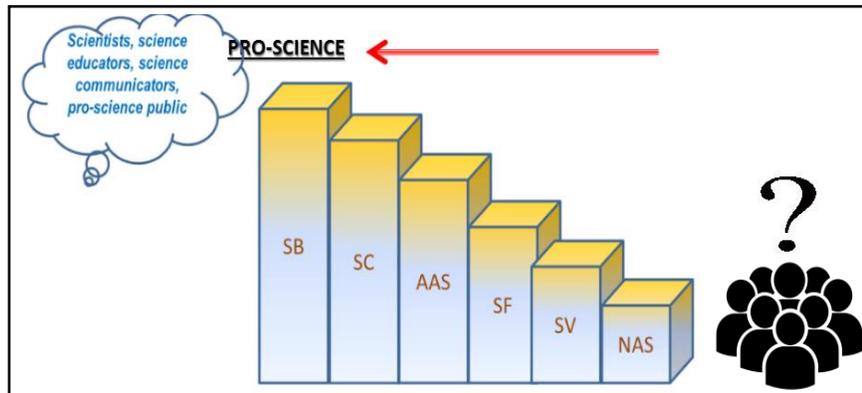


Figure 3 *The six orientations of people regarding their role as science communicators (created by authors according to Ogawa (1998))*

3. 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: 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 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. The general public 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, the class design was planned very well. Additionally, in terms of instructional design, some graduate students explained,

...It gave us more freely as graduate students deal with their creativity. Some examples: 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 (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 also verified 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, such as materials and tools, internet, book references, comics, newspaper, magazine, PowerPoint presentation, LCD, journal papers, and science' 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 (take for example, 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 was used for bridging the student knowledge. The book consisted of theoretical perspectives in social cognition and integration, application, and challenges. Turning to 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: 'radioactivity' to provide insights into how the environment's features may influence student learning. Some participants explained,

The use of ICT in the course helped us to grasp many open educational resources; consequently the discussion became more clear and 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); 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. For the teacher, though, 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 student (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 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. Teachers evaluated the students’ thinking and learning process rather than the students’ knowledge (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,

I emphasised the general interaction and gave some homework's 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,

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).

4. 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 teaching people, just which people can monitor and

understand the activities and the behaviour of scientists. This responsibility is called public awareness.

Based on the participants' experience and feeling, there were many scientific issues from the 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: technology, education, social, 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, Lorenzoni, ..., & Gelcich, 2014; Rabinovich, Morton, & Birney, 2012; van Pelt, Haasnoot, ..., & Biesbroek, 2015), earthquake prediction (Papadopoulos, 2015), and environmental health risks (Friedman, Toumey, ..., & Lead, 2015).

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

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 phenomena that teacher knew or the trend issue in Taiwan (i.e. Dust explosion, Lantern festival), indeed, from around the world (such as World War I and II, endemic disease, SARS, H1N1) were explored into 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 devote to the vegetable? (P2).

The second issue was the nature of science (NOS). Science communication is about science content itself and *the parrot-like talking* and science gossip (Knight, 2006) *versus* rationality and authority. The parrot-like talking is happening when people are repeating everything they heard very annoyingly for no reason and giving inaccurate information. However, the general public 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?, What is happening?”. Professor Cheng thought that social cognition could make people more rational in dealing with science communication issues.

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. Science education focuses on communication methods to reach the public (Aberšek & Aberšek, 2010; Wu et al., 2019).

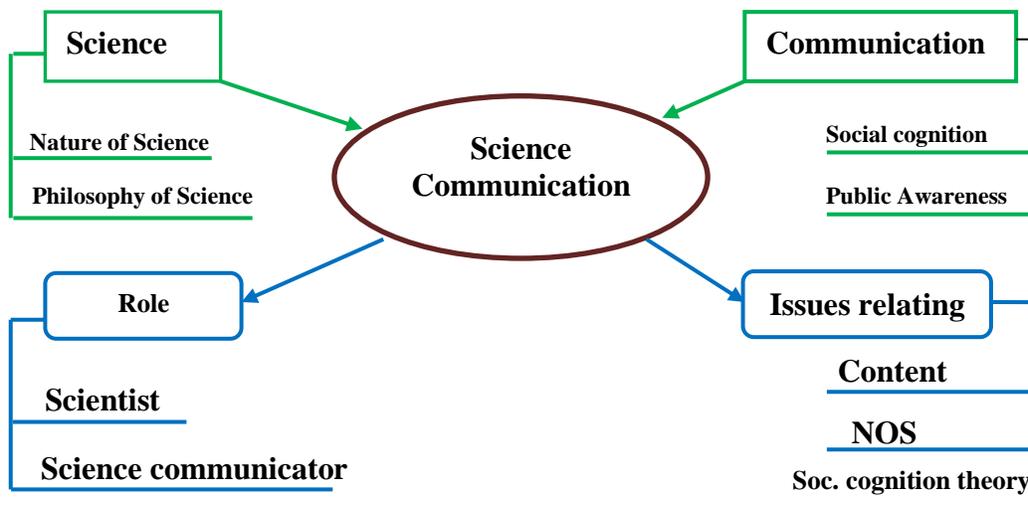


Figure 4 *The key concepts of science communication*

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 language - 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 consider language problems in their interviews.

A science communication course's role is how to communicate scientific knowledge and interconnect it among phenomena around the world. The course's core also represents the relationship among science, technology, and society (STS) 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. The critical learning experiences that can be arrested 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 determining of learning.

Considering the trending issues around science communication can be viewed from three parts: 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 (Pitipornatapin, 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, we know 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 would have to prioritise a science communication course, appropriate learning materials will need to be developed, and space will need to be created in a curriculum. Science always considers a rational discipline. Therefore, when we understand science from philosophy or social cognition, we can find science activity include 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 other graduate students' and professors' learning experiences in other Taiwan universities. Thus, generalisability of the findings to other students and other countries is cautioned. 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 four 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, and 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.

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Appendix

SAMPLE OF TRANSCRIPTS FROM IN-DEPTH INTERVIEW

Topics: Science Communication

Introduction:

Well...To be an honor 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 the question:

RESEARCHER	PARTICIPANT (P1)	P2	P3	P(n).	First coding
<p>What does the course look like? Please use your experiences</p>	<p>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 Studies (STS) 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,</p>	<p>I still remember that learning science communication linked to the philosophy of the bird's beak, initiated by Thomas Khun 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</p>	<p>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 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.</p>	.	Terminology , framework

RESEARCHER	PARTICIPANT (P1)	P2	P3	P(n).	First coding
	technological systems, and society [thinking]...	need some improvement. Yeah... the lack of classroom management.		.	
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 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...		trend issues around science communication
.....