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Research Article

Extraction and recognition of competency components of the STEM human resources community: Focusing on the cultural impacts of Japanese university students

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The importance of human resources in science, technology, engineering, and mathematics (STEM) is increasingly recognized in Japan and other countries worldwide. This study considers the STEM human resources community as a cultural sphere and examines the factors that influence STEM competency elements in a sample of Japanese university students as a preliminary study for an international survey. The study results revealed that out of the 21 competency elements, four—leadership, initiative, ability to control stress, and ethics—were affected by gender, while the other 17 were not affected by gender. Conversely, differences in major field of study were less likely to affect the results. Furthermore, it was confirmed that students' motivation for growth in the 21 competency elements was positively correlated with the 21 competency elements, suggesting that many students in STEM want to improve these competency elements. Future research in this area should include conducting surveys in new countries and regions, as well as in other age groups, such as among high school students and working adults, including examining the concept of the competency model's elements itself.

Keywords: STEM education, Higher education, Competency of STEM community, Nature of STEM, Gender of STEM

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1. Introduction

Several universities in Japan have been sowing seeds of innovation in areas moving beyond the traditional disciplinary approach for teaching science, technology, engineering, and mathematics [STEM], in addition, science, technology, engineering, art, and mathematics [STEAM] education is also being promoted at the research level in higher education. The importance of building interdisciplinary understanding has been gaining recognition worldwide (e.g., Kumano, 2013). Beyond Japan, many countries have been pursuing higher education transformation. For example, the United States government has been promoting STEM competencies as an important means of developing the economy. To this end, they have endeavored to decrease the dropout rate among students in STEM majors (President's Council of Advisors on Science and Technology, 2012), with

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the goal of increasing the number of degrees granted in STEM over the next 10 years by one million. These policies recommend expanding the First-Year Experience Program (a program for incoming undergraduate students), recognizing that fundamental skills are important for developing human resources in STEM.

In Japan, this type of approach is being followed under the "zest for living (ikiruchikara)," which has guided the Japanese government's revised competency model for the course of study (National Curriculum Standards [NCS]) since 2002. The concept of zest for living was first proposed in a report by Japan's Central Council for Education [CCE] (1996), and it includes a wide range of elements. It has remained important in the subsequent revision of NCS, and its cultivation is still emphasized to this day. The definition of zest for living has some nuances depending on the cultural background of the council members and the ministry under which it is being applied, but in this study, I use the CCE's (1996) explanation of the concept:

> It was clear to us that what our children will need in future, regardless of the way in which society changes, are the qualities and the ability to identify problem areas for themselves, to learn, think, make judgments and act independently and to be more adept at problem-solving. We also felt that they need to be imbued with a rich sense of humanity in the sense that while exercising self-control, they must be able to cooperate with others, have consideration for their needs and have a spirit that feels emotion. It also goes without saying that if they are to lead vigorous lives, a healthy body is an indispensable requirement. We decided to use the term zest for living to describe the qualities and abilities needed to live in a period of turbulent change and felt it is important to encourage the right balance between the separate factors underlying this term.

Zest for living comprises the following elements: (1) richness in humanity, (2) health and physical fitness, and (3) academic ability (CCE, 2008). Academic ability is in turn assessed in terms of three categories: (1) knowledge and skills; (2) thinking ability, judgment, and expression; and (3) initiative and collaboration (Japan's Ministry of Education, Culture, Sports, Science and Technology [MEXT], 2007).

In undergraduate education, MEXT has been promoting changes to education methods, such as instituting active learning, interactive lectures, and experimentation through which students can explore problems and find solutions themselves (CCE, 2012). The CCE (2014) asserted that the cultivation of competencies currently included in primary and secondary education, including fostering a zest for living and the three elements of academic abilities should continue in higher education, and this was the reason behind changes to basic education policies in Japanese higher education. In this report (CCE, 2014), for the first time, the Japanese government required universities and other institutions to develop ideal resources to extend those cultivated in primary and secondary education. The educational competency model that had been followed in primary and secondary education was now required to be implemented in higher education as well.

1.1. Competencies

In Japan, the concept of competency has been used in corporate recruitment and human resource management, and presently, it is being used in higher education. MEXT used the term in the summary of deliberations for the CCE's (2008b) report, although it was not included in the final report. Yachi (2001) cites three reasons for the popularity of the competency concept in Japan: (1) a paradigm shift from functional to strategic human resources [HR], (2) institutional and operational deficiencies in the evaluation system based on the job qualification system, and (3) the global standardization of HR systems.

Based on the history of Japan's HR management system after World War II, Iwawaki (2007) argued that the collapse of the bubble economy in the early 1990s led to a paradigm shift from a focus on potential to manifest ability (results). This notion was imported from the United States to compensate for the shortcomings of the qualification system, which ranked employees according to their specific qualifications by promoting a performance-based system instead. Consistent with these changes in the industrial world, research on vocational relevance (the usefulness of school education for the skills required for jobs) in school education began to develop (e.g., Japan Institute for Labour Policy and Training, 2005). Iwawaki (2007) described that in education the concept referred to minimum standards, unlike in industry, because the social background of Japanese society, where new graduates are hired en masse, requires developing HR who do not have expertise in a specific field. Therefore, the CCE (2008b) defined competency as follows: "A concept that focuses on the ability to carry out and solve work-related problems by making full use of knowledge and skills, rather than on the knowledge and skills themselves."

One of the quality assurance measures for Japanese universities is the accreditation system, which requires an external evaluation of the management system, curriculum, and quality of faculty members once every seven years. Several organizations conduct these external evaluations, and one of them, the Japan University Accreditation Association [JUAA], compiled a glossary of terms that included the following definition of competency:

> Behavioral characteristics that lead to high performance and results. Behavioral characteristics are characteristics that are expressed through the combination of "thinking" and "action". It is a way of thinking that aims to improve organizational performance and results by finding the behavioral characteristics that lead to results for a specific goal and utilizing them in the evaluation standards in the field. In recent years, some universities have positioned these skills as "abilities expected to be acquired upon graduation", and some use their own indicators such as "communication skills" and "problem-solving skills". (JUAA, 2020)

The Japan's Cabinet Office (2016) promoted the idea of Society 5.0, a human-centered society that balances economic advancement with the attempt to resolve social problems through a system that deeply integrates cyberspace with physical spaces. As part of Society 5.0, the Minister's Meeting on Human Resource Development for Society (2018) defined STEM and citizen common competences as the "ability to accurately interpret and respond to writing and information, ability to engage in and apply scientific thinking and inquiry, and sensitivity and ability to discover and create value, curiosity, and inquisitiveness."

The Japan's Ministry of Economy, Trade and Industry [METI] (METI, 2006) has promoted the idea of "fundamental competencies for working persons". Society (especially Japanese society) has long demanded HR with the basic skills necessary to work in organizations and communities. These skills largely comprise 12 competencies in the following three categories: (1) ability to step forward (action)—composed of initiative, ability to influence, and execution; (2) ability to think through (thinking)—composed of ability to detect issues, planning skills, and creativity; and (3) ability to work on a team (teamwork)—composed of ability to deliver messages, ability to listen closely and carefully, flexibility, ability to understand situations, ability to apply rules and regulations, and ability to control stress. Many skill sets, competency models, and frameworks are available, for example, 21st-century skills (Partnership for 21st Century Skills, 2009) and key competencies (Rychen & Salganik, 2003). These competency models share many keywords and include similar constructs. However, the definition of competency itself exists as multiple concepts, likely because the concept encompasses not only behavior but also thinking and is deeply connected to the educational system, social system, and cultural background.

Research dealing with such concepts note that it is difficult to conduct surveys that involve comparisons between individuals because their individual backgrounds have great impact, particularly their cultural backgrounds (Aikawa, 2007). This is because it can be difficult to identify which individual or group factors influenced the results. However, recent studies have shown that socio-emotional skills, such as perseverance, sociability, and self-esteem, can be effectively compared among people who have the same cultural background (Organization for Economic Co-operation and Development [OECD], 2015). Thus, in this study, I compare university students' importance of STEM HR competency components (ability elements) and motivation for learning in Japan, who can be presumed to have the same cultural background, in accordance with Aikawa (2007).

1.2. Influence of Cultural Backgrounds

To meet the growing global demand for STEM professionals, it is necessary to clarify the required competencies, incorporate them into training curricula, and develop evaluation indicators. In STEM workforce development, researchers have actively focused on the roles of learners' cultural backgrounds (e.g., Santiago, 2017). United Nations Educational, Scientific and Cultural Organization [UNESCO] (2019) classified STEM competencies into three categories: (1) knowledge, (2) skills, and (3) attitudes and values. Additionally, the Global STEM Alliance (2016) identified core competencies that comprise seven essential skills as students must develop to thrive in the modern workplace (Critical Thinking, Problem Solving, Creativity, Communication, Collaboration, Data Literacy, Digital Literacy & Computer Science) and five supporting attributes as facilitate the development of and enhance these essential skills (STEM Mindset, Agency & Persistence, Social & Cultural Awareness, Leadership, Ethics). However, these previous researchers did not fully address any of the characteristics, attitudes, and perceptions of STEM students. Also important is research that considers factors that influence the importance and development of these STEM competencies, such as gender and learning history (e.g., Aikawa, 2007; OECD, 2015). Developing competency skills in students requires considering their motivations for pursuing competency (Kato, 2011), which will be important for building and contributing to the STEM HR community. Also, STEM consists of multiple disciplines, this it is necessary to consider whether STEM fields can be grouped or if there are different understandings of STEM competencies by discipline.

Previous studies have focused on students' attitudes toward STEM and their achievement in various fields, from early childhood education to higher education and working adults. For example, Libertas Consulting (2018), a study commissioned by the Cabinet Office that focused on attitudes toward STEM fields, found that 58.2% of all students in junior high school were uncomfortable with learning STEM fields while 38.4% of female students and 28.1% of male students seeing STEM careers as "cool". Dasgupta and Stout (2014) mention that cultural factors created by gender differences affect learning motivation and that it varies greatly depending on parental support, peer approval, and the interests of same-sex friends. In addition, the development of educational programs that focus on gender differences has been popular in primary and secondary education. It has been shown that learning motivation can be maintained by teachers devising teaching methods that are responsive to gender differences (e.g., Wieselmann et al., 2020).

Creating a competency model requires identifying and analyzing the characteristics of STEM HR and then building the model by focusing on these specific characteristics, including behaviors (Ogata, 2001). Conversely, it is also possible to derive competency elements through discussions among experts who examine these elements from the perspectives of systems and other factors (e.g., Makino, 2013). Because this study aimed to create a competency model for the STEM HR community based on Japan's education policy and industry policies for education, I adopted the latter method of examining and deriving elements for the different competency models discussed above. One aim of this study is that by identifying the relevant competencies for the STEM HR community, students who are the future STEM workforce can play an active role in the contemporary era of volatility, uncertainty, complexity, and ambiguity. Thus, I identified competency elements that would be relevant to the STEM students. In this study, to derive a competency model that would be less susceptible to cultural influences that differ from STEM expertise, I conducted a survey of Japanese university students' perceptions of the relevant components of STEM competency. The following research questions guided the study:

RQ 1) Do gender and the major field of study impact self-assessment of the importance of STEM HR competencies ability elements?

RQ 2) Are students in a situation of awareness that enables them to develop ability elements effectively?

2. Method

In this study, I conducted a survey of Japanese university students majoring in STEM fields to determine their perceptions of the components that comprise relevant STEM HR competencies. These competencies were based on Japan's education policy, NCS, and the unique HR development policies of several Japanese government agencies. Following the methodology of Makino (2013), I investigated the students' perceptions of the ability elements of the STEM competency model.

2.1. Influence of Cultural Backgrounds

First, I created a list of ability elements based on the competency model and keywords proposed in policy documents of government agencies, such as MEXT and METI, as well as in NCS. The list was created based on the ability elements and keywords proposed in the literature on STEM and STEM fields. For that reason, the list does not focus on specific STEM fields but on a list of competencies that are independent of the field.

2.2. Extracting a List of Ability Elements

The curriculum for primary and secondary education in Japan is revised about once every 10 years to update the skills to be cultivated, establish new subjects, and provide detailed information on teaching and evaluation methods. In contrast, in higher education, universities develop their own curricula, and quality is regularly confirmed when faculty are newly hired or reorganized, as well as through accreditation evaluation every seven years. Furthermore, university leaders determine the abilities to be cultivated and the direction of these abilities using the Central Council for Education reports and the requirements for subsidies for university management.

Based on this background, I constructed the initial ability elements of STEM HR competencies list based on not only the primary and secondary NCS but also on (1) six reports by the MEXT and CCE (A: for primary and secondary education, B: for higher education, and C: for graduate education), (2) two METI industry skill sets and reports, one of which is "fundamental competencies for working persons" (METI, 2006), and (3) five reports and policies compiled by the Cabinet Office and the Prime Minister's Office. From these sources, I identified 37 ability elements. Table 1 provides a summary of these 37 competency factors extracted from the 13 documents and the number of cases in each category. The number of cases indicates the number of materials that corresponded to each category.

In order to examine the competency model from the perspective of Japan's education system and various policies, I decided to extract elements common to these three categories (1) education policy, (2) industry, and (3) the government as a whole, such as the Cabinet, as the ability elements that make up the STEM HR competency model. For this purpose, 37 ability elements were extracted from 13 documents in the three categories, and the 21 ability elements common to the three categories were set as items to be used in the questionnaire survey of this study. Many of these items have much in common with the "fundamental competencies for working persons" (11 of the 12 competency elements apply) used in (2) those related to industry. The referenced documents, etc., do not include competencies specific to STEM human resources, but rather competencies that do not depend on the field. However, rather than constructing a role model of a highly competent STEM workforce, this study focuses on what students in the STEM community think about the ability elements that make up discipline-independent competencies, in order to identify the ability elements required of the next generation of STEM workers. This extraction method is consistent with the purpose of this study and is based on Makino's (2013) methodology.

Table 1
Initial List of 37 Ability Elements and Classification

	1) Education policy (MEXT)	2) Industry (METI)	3) Others (such as the Cabinet)
Expertise (general)	1	1	2
Leadership	1	1	4
Management	2	1	2
Information, media, and technology literacy	2	1	3
Initiative	2	2	1
Ability to influence others	2	1	1
Executing plans	2	2	2
Ability to detect issues	4	2	2
Creativity	2	2	3
Critical thinking	3	1	2
Collaboration	4	1	1
Communication	4	1	4
Innovation	1	1	1
Ability to deliver messages	2	1	2
Ability to listen closely and carefully	2	1	2
Flexibility	1	1	2
Ability to grasp situations	1	1	2
Ability to apply rules and regulations	1	1	1
Ability to control stress	1	1	1
Ethics	2	1	1
Career development and planning	1	1	1
Planning skills	0	1	1
Knowledge	3	0	1
Ability to think	2	0	1
Ability to make decisions	1	0	0
Ability to express oneself	2	0	0
Skills	1	0	1
Diversity	2	0	3
Self-management	2	0	1
Sense of responsibility	1	0	1
Sense of mission	0	0	1
Japanese identity	0	1	1
Publicness	0	0	1
Design skills	0	1	0
Design philosophy	0	1	0
Entrepreneurship	0	1	1
Facilitation	0	1	0

The 21 ability elements common to the three extracted categories are (1) Expertise (general), (2) Leadership, (3) Management, (4) Information, Media, and Technology Literacy, (5) Initiative, (6) Ability to Influence Others, (7) Executing Plans, (8) Ability to Detect Issues, (9) Creativity, (10) Critical Thinking, (11) Collaboration, (12) Communication, (13) Innovation, (14) Ability to Deliver Messages, (15) Ability to Listen Closely and Carefully, (16) Flexibility, 17) Ability to Grasp Situations, (18) Ability to Apply Rules and Regulations, (19) Ability to Control Stress, (20) Ethics, (21) Career Development and Planning. Table 2 provides a summary of 21 ability elements and each definition.

Table 2
Lists and Definitions of 21 Ability Elements

	Definitions of Ability Elements	*References*
Expertise (general)	Advanced knowledge, experience, and skills in the fields of STEM.	Created by the author based on Council on Promotion of Human Resource for Globalization Development (2011), CCE (2018), and METI (2019).
Leadership	A mindset that is willing to take risks, start something new, and take the initiative to change the status quo.	Author's translation of the definition of METI (2018).
Management	Ability to plan, organize, lead, and control using knowledge of STEM expertise in the context of projects, activities, operations, maintenance, quality, risk, change, and business and more.	Created by the author based on International Engineering Alliance (2013) and MEXT (2014).
Information, media, and technology literacy	Ability to effectively use ICT to collect and analyze a variety of information based on moral and rules.	Author's translation of the definition of CCE (2008c).
Initiative	Ability to initiate things proactively.	The definition of METI (2006) translated by METI.
Ability to influence others	Ability to influence and involve others.	The definition of METI (2006) translated by METI.
Executing plans	Ability to clarify procedures to solve issues, prepare and execute with conviction.	Created by the author based on METI (2006) and METI (2019).
Ability to detect issues	Ability to analyze status quo and clarify issues.	The definition of METI (2006) translated by METI.
Creativity	Ability to create new values.	The definition of METI (2006) translated by METI.
Critical thinking	Ability to think with a carefully perspective rather than unconditionally accepting assumptions and contexts.	Created by the author based on METI (2019).
Collaboration	Ability to interact with people from diverse backgrounds with different cultures, ways of thinking, and values, and deal with them effectively and respectfully to achieve common goals and work together.	Created by the author based on METI (2019).
Communication	Ability to form human relationships and teamwork while deepening mutual relationships and empathy in a group of people with various values and backgrounds, to share information through dialogue about issues that have no correct answers and problems that have never been experienced, to think deeply on one's own, and to build consensus and solve problems while mutually communicating and deepening one's thoughts.	Author's translation of the definition of MEXT (2011).
Innovation	Ability to generate new value through scientific discovery or invention, development of new products or services, or other creative activities, and through the dissemination thereof, create great change in the economic society.	The definition of The Basic Act on Science, Technology and Innovation (2021) translated by Cabinet Office (2021).
Ability to deliver messages	Ability to delivery own opinions clearly.	The definition of METI (2006) translated by METI.

Table 2 continued

	Definitions of Ability Elements	*References*
Ability to Listen Closely and Carefully	Ability to listen to other peoples' opinions carefully.	The definition of METI (2006) translated by METI.
Flexibility	Ability to appreciate different opinions and perspectives.	The definition of METI (2006) translated by METI.
Ability to Grasp Situations	Ability to comprehend relationship between yourself and other people as well as things surrounding you.	The definition of METI (2006) translated by METI.
Ability to Apply Rules and Regulations	Ability to comply with social rules and keep promises with others.	The definition of METI (2006) translated by METI.
Ability to Control Stress	Ability to deal with the original cause of stress.	The definition of METI (2006) translated by METI.
Ethics	Ability to judge and act on required actions, words, and behaviors through knowledge and skills essential to the performance of responsible activities.	Created by the author based on Council on Promotion of Human Resource for Globalization Development (2011), Japan Society for the Promotion of Science（2015, CCE (2018), and METI (2019).
Career Development and Planning	Ability to make independent judgments and formulate careers while appropriately discerning and utilizing a variety of information about various.	Author's translation of the definition of CCE (2011).

2.3. Survey: Perceptions of Ability Elements

2.3.1. Data collection

This study aimed to examine the influence of cultural background, such as gender and major, in Japan, on students' perceptions of the importance of difference STEM competencies. To address my two study aims, identifying how the competency elements the students identified differed by gender and course of study and the importance to the students of pursuing competency in these elements, I conducted a survey of Japanese university students majoring in STEM fields. Specifically, I asked two questions: Q1, "How important are these skills and abilities for people with STEM careers?" and Q2, "How much would you like to improve your skills/abilities in the future?" Students were asked to answer both questions about each of the 21 ability elements on 5-point Likert scales. The options for Q1 were as follows: "5: very important," "4: important," "3: somewhat important," "2: not very important," and "1: not at all important"; the choices for Q2 were as follows: "5: very much," "4: much," "3: some," "2: a little," and "1: not at all."

The respondents were first-year students in the science department of a national university. The university in question operates on a quarter system, and the survey took place at the end of the second quarter. The number of respondents was 228, of whom 172 were men and 56 were women. By subject, the students were majoring in mathematics: 49, physics: 51, chemistry: 46, biology: 45, and geology: 37. Approximately 30% of the undergraduates from this university enter industry, about 30% become educators, and the remaining 30% go on to graduate school.

2.3.2. Data analysis

Based on the results of university students' responses to Q1 and Q2, this study examined the ability elements required by the STEM HR community that university students majoring in STEM fields have. In order to do so, I summarized and discussed the results in four stages: (1) comparison of the effects of gender, (2) comparison of the effects of major field of study, (3) comparison of learning motivation toward ability elements, and (4) examination of the importance and motivation toward ability elements.

In (1), a *t*-test was used to check for significant differences in the gender comparison, and in (2), an analysis of variance was used because there were five fields of study (mathematics, physics, chemistry, biology, and geology). In both cases, if a significant difference is confirmed, it means that there is a difference in the perception of the importance of ability elements depending on the comparison factors, and this leads to the identification of important factors that should be taken into consideration when considering curricula and programs. This is equivalent to confirming what Tominaga (2018a, 2018b) mentioned, that gender affects the perception of competency and that it is important to devise educational methods according to the characteristics of that perception.

For (3), I examined the learning motivation for the ability elements and for (4), I analyzed the correlation between the perception of importance for ability elements and learning motivation. Of course, respondents' self-perception of their proficiency in ability elements may significantly affect learning motivation. However, since the university students in this study are in the middle of the academic entry-level of Japanese universities, they are representative of the characteristics of students studying STEM fields in Japan. The importance of this motivation for learning has been mentioned by Horie et al. (2007) and others, and it is a factor that needs to be considered to support innovation in STEM HR for the future.

3. Results and Discussion

To address the initial study aims, I compiled and analyzed the students' responses to Q1 and Q2 to examine Japanese students' views on elements of competency for the STEM HR community. I first discuss the Q1 results for the influence of gender and major course of study and then address how the students rated the importance to them of mastering the individual components.

3.1. Gender Effects on Ability Elements Ratings

Figure 1-3 summarizes the Q1 results for all respondents according to gender. In each figure, the items are listed in the order of the number of positive responses (very important or important). In order to analyze the characteristics of each item, Table 3 summarizes the results of the comparison by the number of respondents who responded positively (rating the item as very important or important).

For all respondents in Q1, five items (Executing Plans, Ability to Detect Issues, Creativity, Expertise (general) and Flexibility) were above 90%, and 11 items (Executing Plans, Ability to Detect Issues, Creativity, Expertise (general), Flexibility, Ability to Grasp Situations, Critical Thinking, Initiative, Ability to Influence Others, Communication and Ability to Listen Closely and Carefully) were above 80%. For males, there was an additional item above 90%, Ability to Grasp Situations, and also an additional item for above 80%, leadership. In contrast, while females included the 5 items above 90% and only 10 items above 80%, unlike their male peers females did not include initiative and leadership.

When comparing the top five items in terms of the number of positive responses, four items were common among male and female (Ability to Detect Issues, Creativity, Executing Plans, Expertise (general)), but the only item that was ranked the same was "Executing Plans," which was ranked first. This result suggests that there may be a differences between male and female, so a *t*-test was conducted for more detailed analysis.

For a more detailed analysis, Table 4 shares differences by gender related to the perceived importance of each specific competency. Four items (Leadership, Initiative, Ability to Control Stress and Ethics) were found to be significantly different by gender. As all students experienced Japan's NCS for secondary education, differences in these four items are most likely influenced by aspects of Japanese culture other than the education system. For example, ethics is deeply connected to not only learning but also to life and society, suggesting cultural influences beyond school.

For the 21 items, many of the items were higher for females, while for the four items where a significant difference was confirmed, three of the things were higher for males, and one was higher for females. Males are statistically more likely to believe that it is crucial for STEM HR to take leadership and initiative toward others and to control stress. Leadership and initiative are vital in encouraging others to take action, which can be highly stressful when the situation differs from one's intentions. It is also possible that research in STEM fields is stressful in itself and that because they believe that initiative is essential, they are also focusing on its counterpart, stress. On the other hand, females emphasize communication skills to cooperate with others and believe that a high sense of ethics is necessary to achieve this. The finding of gender differences was consistent with findings from previous studies, such as Tominaga (2018a, 2018b), that gender affects perception of STEM competencies.

Figure 1
Results of importance perceptions (Q1: All respondents)

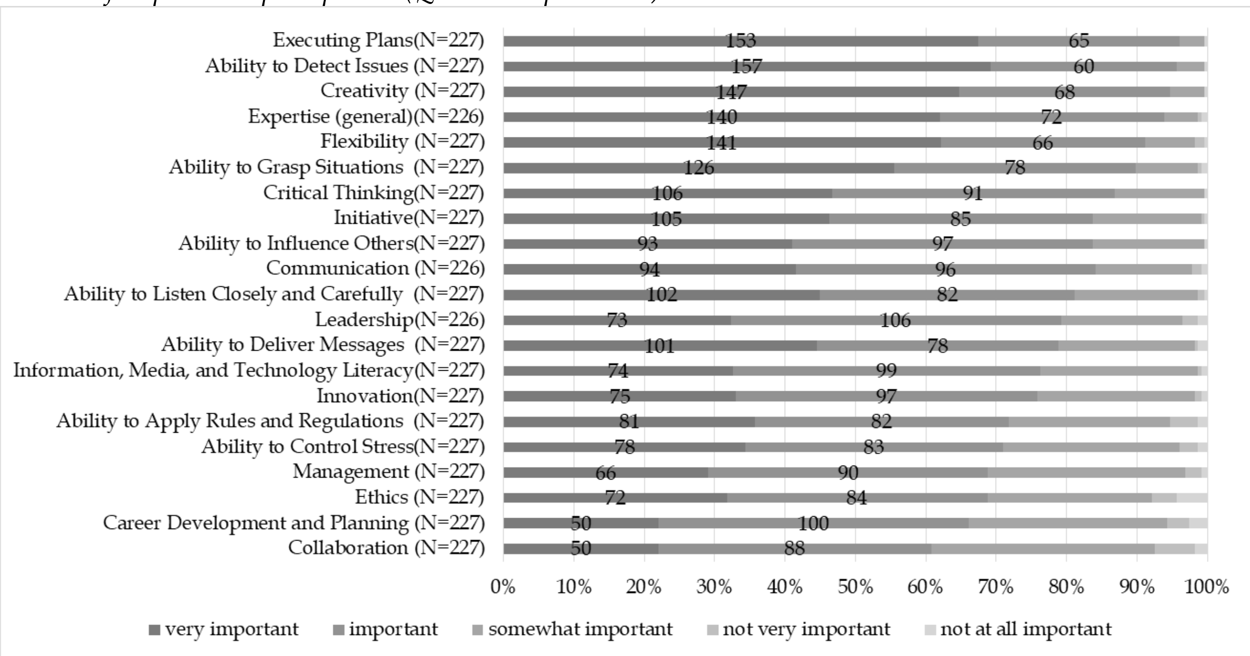

Figure 2
Results of importance perceptions (Q1: Male)

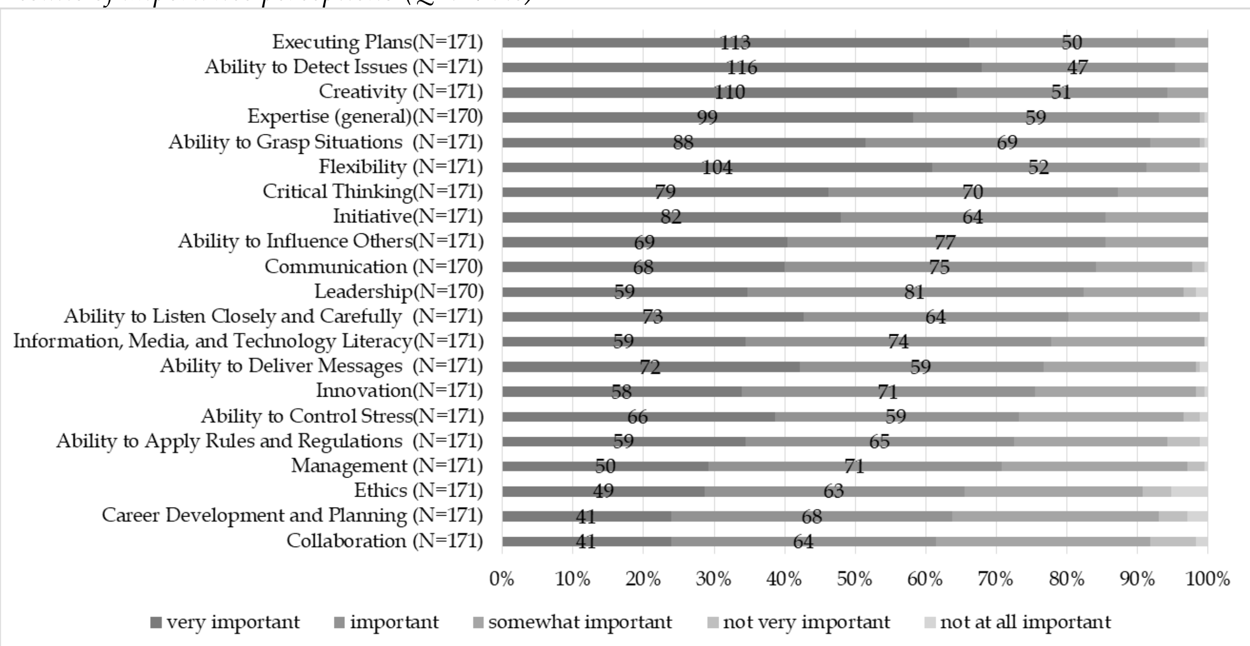

Figure 3
Results of importance perceptions (Q1: Female)

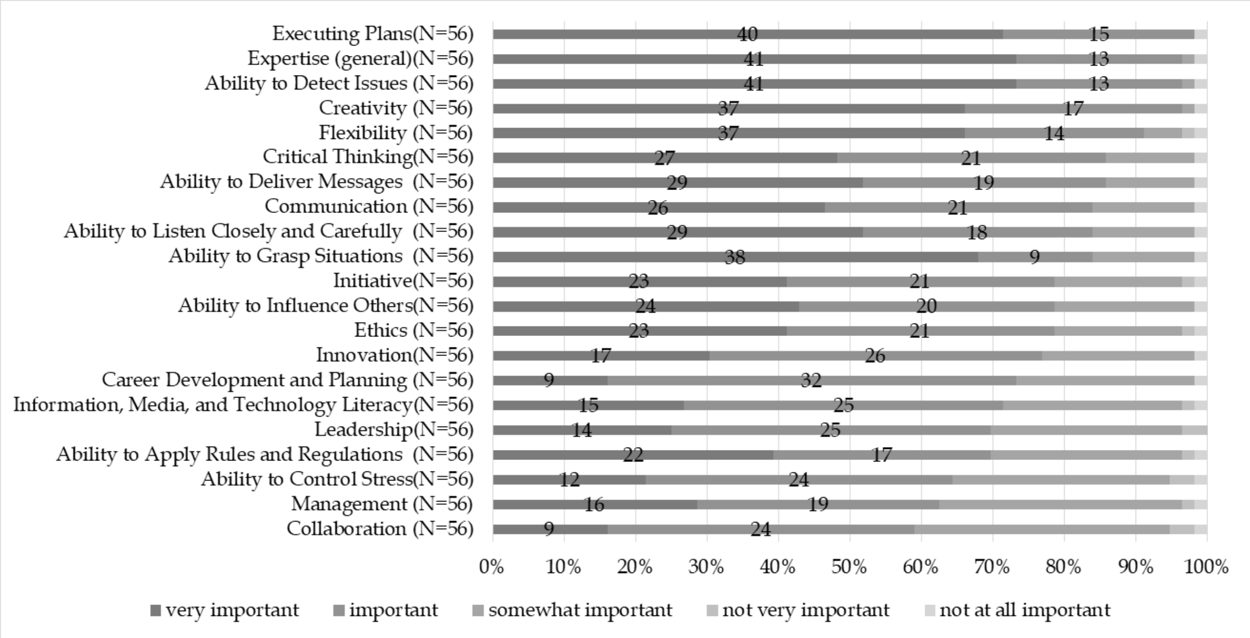

Table 3
Comparison of positive responses to Q1 by gender

All Respondents			*Male*			*Female*		
	Positive Response N	%		Positive Response N	%		Positive Response N	%
Executing plans	218	96.0	Executing plans	163	95.3	Executing plans	55	98.2
Ability to detect issues	217	95.6	Ability to detect issues	163	95.3	Expertise (general)	54	96.4
Creativity	215	94.7	Creativity	161	94.2	Ability to detect issues	54	96.4
Expertise (general)	212	93.8	Expertise (general)	158	92.9	Creativity	54	96.4
Flexibility	207	91.2	Ability to grasp situations	157	91.8	Flexibility	51	91.1
Ability to grasp situations	204	89.9	Flexibility	156	91.2	Critical thinking	48	85.7
Critical thinking	197	86.8	Critical thinking	149	87.1	Ability to deliver messages	48	85.7
Initiative	190	83.7	Initiative	146	85.4	Communication	47	83.9
Ability to influence others	190	83.7	Ability to influence others	146	85.4	Ability to listen closely and carefully	47	83.9
Communication	190	84.1	Communication	143	84.1	Ability to grasp situations	47	83.9
Ability to listen closely and carefully	184	81.1	Leadership	140	82.4	initiative	44	78.6
Leadership	179	79.2	Ability to listen closely and carefully	137	80.1	Ability to influence others	44	78.6
Ability to Deliver Messages	179	78.9	Information. Media. and Technology Literacy	133	77.8	Ethics	44	78.6
Information, media, and technology literacy	173	76.2	Ability to deliver messages	131	76.6	Innovation	43	76.8

Table 3 continued

All Respondents	Positive Response N	%	Male	Positive Response N	%	Female	Positive Response N	%
Innovation	172	75.8	Innovation	129	75.4	Career development and planning	41	73.2
Ability to apply rules and regulations	163	71.8	Ability to control stress	125	73.1	Information, media, and technology literacy	40	71.4
Ability to control stress	161	70.9	Ability to apply rules and regulations	124	72.5	Leadership	39	69.6
Management	156	68.7	Management	121	70.8	Ability to apply rules and regulations	39	69.6
Ethics	156	68.7	Ethics	112	65.5	Ability to control stress	36	64.3
Career development and planning	150	66.1	Career development and planning	109	63.7	Management	35	62.5
Collaboration	138	60.8	Collaboration	105	61.4	Collaboration	33	58.9

Table 4

T-Test Results for Students' Ratings of STEM Competency Elements by Gender

	Male Mean (SD)		Female Mean (SD)	*t*	df
Expertise (general)	4.49(0.690)		4.66(0.695)	−1.56	224
Leadership *	4.12(0.841)	>	3.91(0.815)	1.61	224
Management	3.96(0.839)		3.86(0.923)	0.813	225
Information, Media, and Technology Literacy	4.11(0.778)		3.93(0.871)	1.48	225
Initiative *	4.33(0.719)	>	4.14(0.903)	1.61	225
Ability to Influence Others	4.26(0.697)		4.18(0.876)	0.686	225
Executing Plans	4.61(0.577)		4.66(0.668)	−0.505	225
Ability to Detect Issues	4.63(0.573)		4.66(0.695)	−0.313	225
Creativity	4.58(0.602)		4.59(0.708)	−0.0464	225
Critical Thinking	4.33(0.695)		4.30(0.829)	0.265	225
Collaboration	3.75(0.951)		3.68(0.855)	0.530	225
Communication	4.21(0.786)		4.27(0.842)	−0.455	224
Innovation	4.07(0.816)		4.04(0.830)	0.273	225
Ability to Deliver Messages	4.16(0.863)		4.34(0.837)	−1.37	225
Ability to Listen Closely and Carefully	4.22(0.786)		4.32(0.855)	−0.849	225
Flexibility	4.51(0.689)		4.52(0.831)	−0.0812	225
Ability to Grasp Situations	4.42(0.701)		4.48(0.874)	−0.582	225
Ability to Apply Rules and Regulations	4.00(0.927)		4.04(0.953)	−0.249	225
Ability to Control Stress**	4.07(0.905)	>	3.79(0.889)	2.05	225
Ethics **	3.80(1.07)	<	4.14(0.903)	−2.19	225
Career Development and Planning	3.78(0.957)		3.86(0.749)	−0.640	119

Note. $*: p < .1$; $**: p < .05$

3.2. Course of Study Effects on Ability Elements Ratings

Figure 4-8 present the students' responses to Q1 by major course of study. Table 5 summarizes the results of the comparison by the number of respondents who responded positively to an item, rating it as important or very important.

Although there were variations in the number of items that received 90% or more positive responses in each major fields (mathematics: 5, physics: 4, chemistry: 7, biology: 6, geology: 8) and the number of items that received 80% or more positive responses (mathematics: 8, physics: 10, chemistry: 15, biology: 10, geology: 17), when the top five items were compared, three items (Expertise (general), Executing Plans and Ability to Detect Issues) were common to all major course of studies, and Creativity was common to four major course of studies (mathematics, physics, chemistry, and geology). No significant differences were found among the respondents according to their majors, which is consistent with Aikawa's (2007) finding that the fields of study that make up the STEM HR community are part of the same cultural sphere. Thus, it is possible to examine competency elements as part of the cultural sphere of the STEM HR community because the different disciplines appear to give similar emphasis to each ability elements of STEM competency.

Figure 4
Results of importance perceptions (Q1: Mathematics)

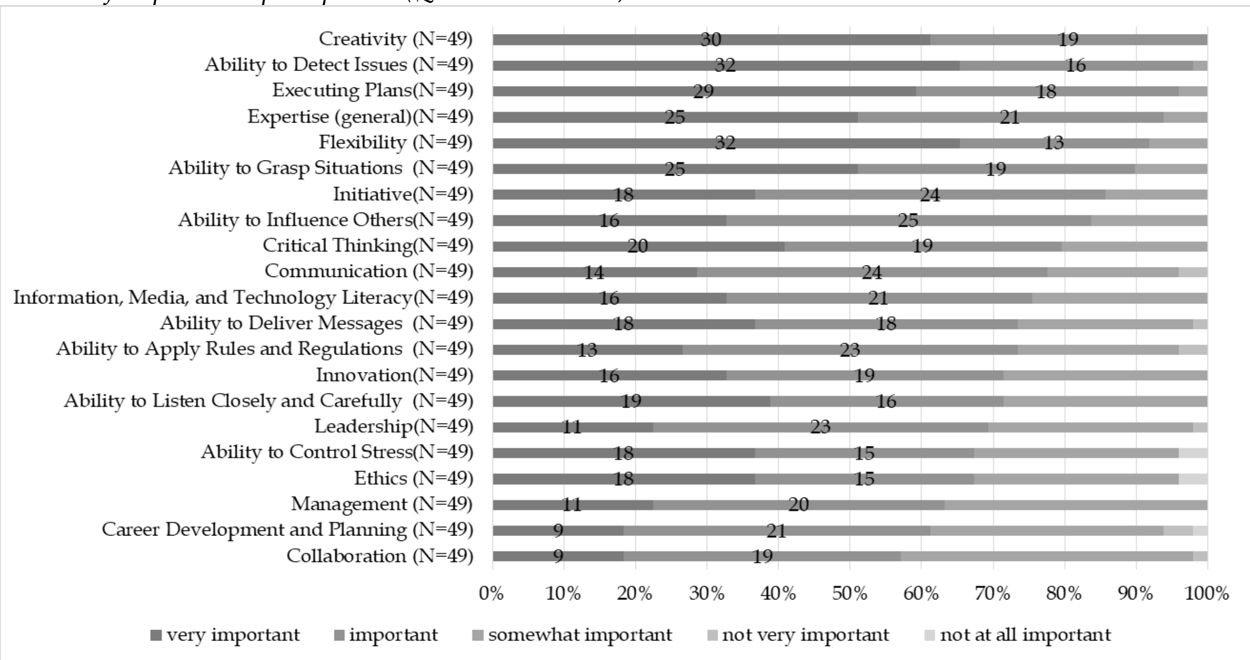

Figure 5
Results of importance perceptions (Q1: Physics)

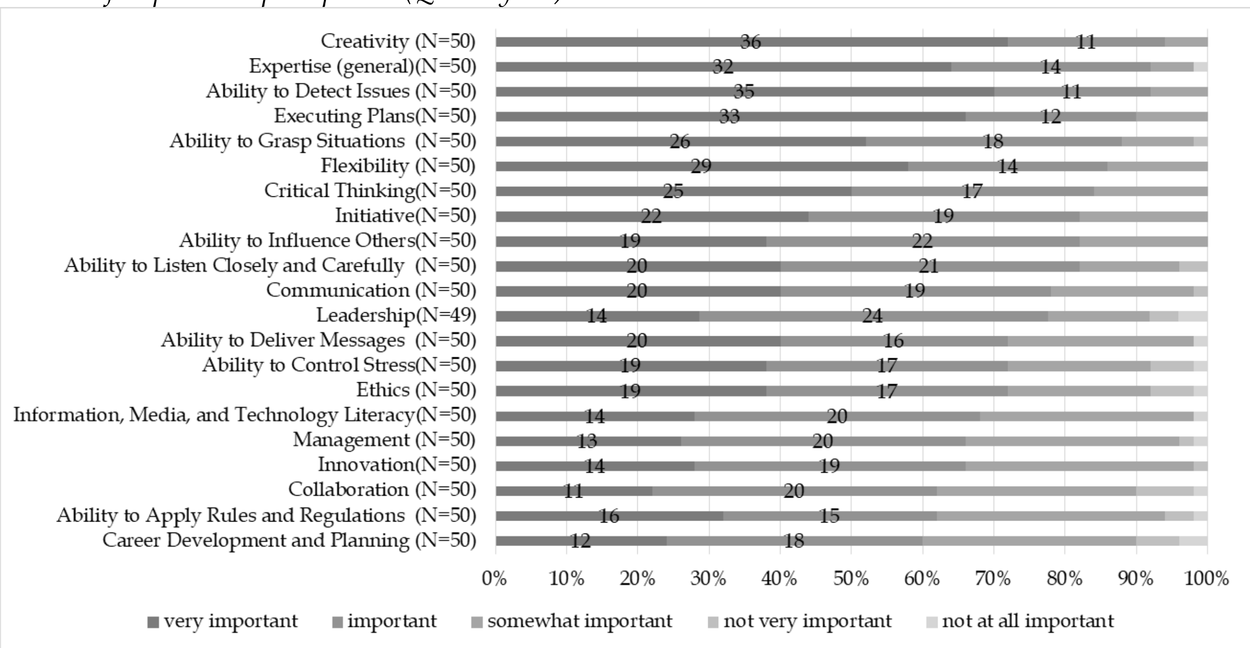

Figure 6

Results of importance perceptions (Q1: Chemistry)

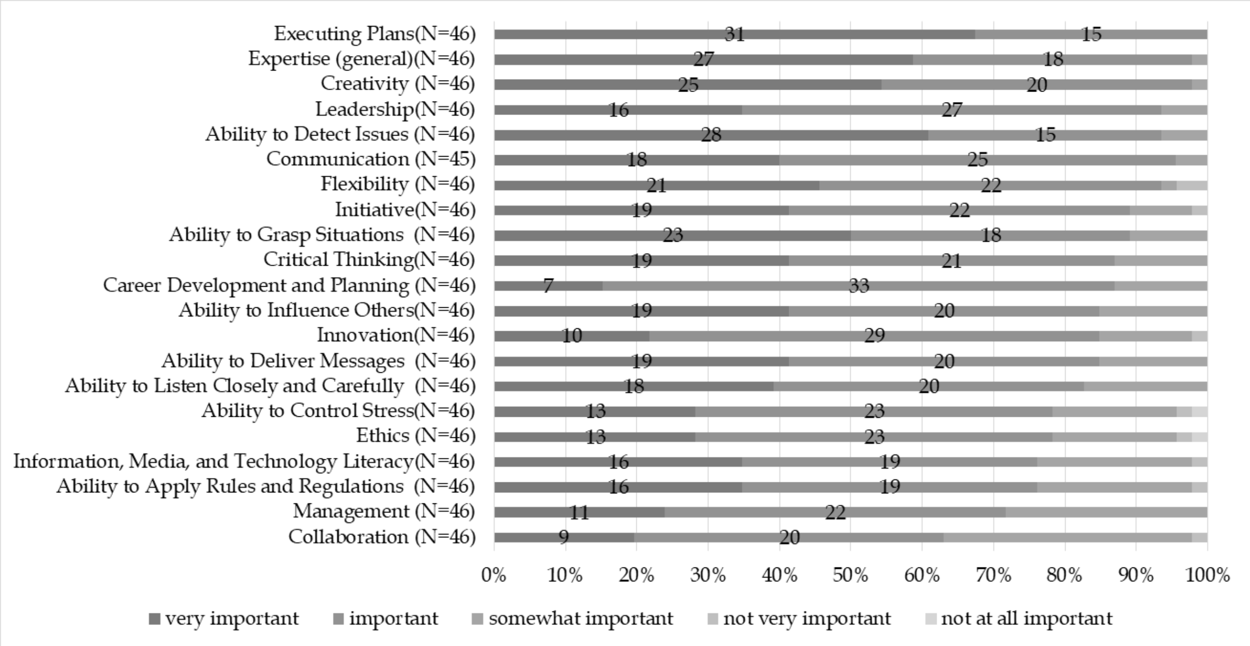

Figure 7

Results of importance perceptions (Q1: Biology)

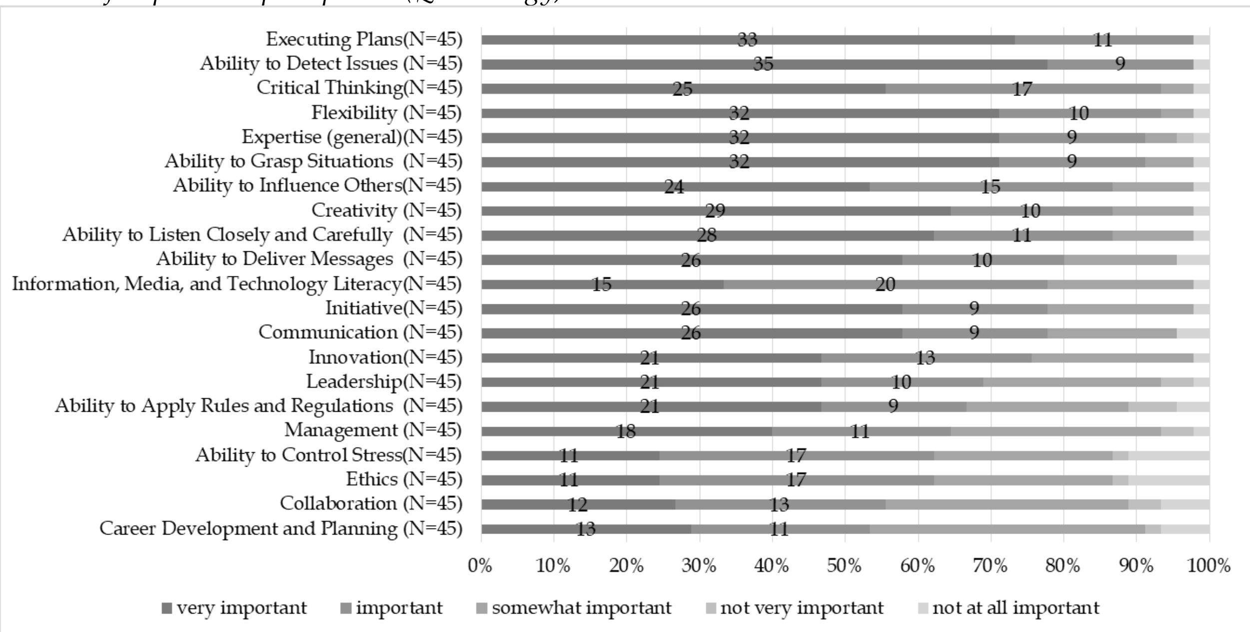

Figure 8

Results of importance perceptions (Q1: Geology)

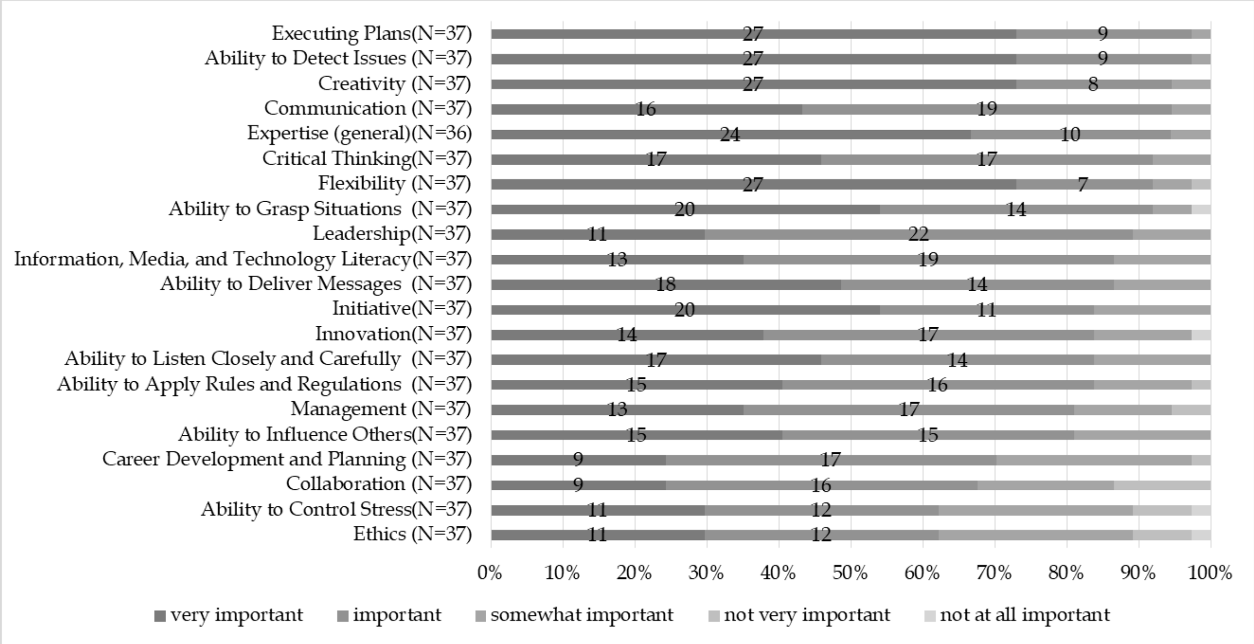

Table 5

Comparison of positive responses to Q1 by major

	All Respondents		Mathematics		Physics		Chemistry		Biology		Geology	
	Positive Response N	%	Positive Response N	%	Positive Response N	%	Positive Response N	%	Positive Response N	%	Positive Response N	%
Expertise (general)	212	93.8	46	93.9	46	92.0	45	97.8	41	91.1	34	94.4
Leadership	179	79.2	34	69.4	38	77.6	43	93.5	31	68.9	33	89.2
Management	156	68.7	31	63.3	33	66.0	33	71.7	29	64.4	30	81.1
Information, media, and technology literacy	173	76.2	37	75.5	34	68.0	35	76.1	35	77.8	32	86.5
Initiative	190	83.7	42	85.7	41	82.0	41	89.1	35	77.8	31	83.8
Ability to influence others	190	83.7	41	83.7	41	82.0	39	84.8	39	86.7	30	81.1
Executing plans	218	96.0	47	95.9	45	90.0	46	100.0	44	97.8	36	97.3
Ability to detect issues	217	95.6	48	98.0	46	92.0	43	93.5	44	97.8	36	97.3
Creativity	215	94.7	49	100.0	47	94.0	45	97.8	39	86.7	35	94.6
Critical thinking	197	86.8	39	79.6	42	84.0	40	87.0	42	93.3	34	91.9
Collaboration	138	60.8	28	57.1	31	62.0	29	63.0	25	55.6	25	67.6
Communication	190	84.1	38	77.6	39	78.0	43	95.6	35	77.8	35	94.6
Innovation	172	75.8	35	71.4	33	66.0	39	84.8	34	75.6	31	83.8
Ability to deliver messages	179	78.9	36	73.5	36	72.0	39	84.8	36	80.0	32	86.5
Ability to listen closely and carefully	184	81.1	35	71.4	41	82.0	38	82.6	39	86.7	31	83.8
Flexibility	207	91.2	45	91.8	43	86.0	43	93.5	42	93.3	34	91.9
Ability to grasp situations	204	89.9	44	89.8	44	88.0	41	89.1	41	91.1	34	91.9
Ability to apply rules and regulations	163	71.8	36	73.5	31	62.0	35	76.1	30	66.7	31	83.8
Ability to control stress	161	70.9	33	67.3	36	72.0	36	78.3	28	62.2	23	62.2
ethics	156	68.7	33	67.3	36	72.0	36	78.3	28	62.2	23	62.2
Career development and planning	150	66.1	30	61.2	30	60.0	40	87.0	24	53.3	26	70.3

3.3. Effects of Students' Learning Motivation for Competency in Each Ability Elements

Figure 9 summarizes the results of the Q2 responses with the items listed in order starting with item with the highest number of positive responses related to the degree to which they would like to improve their ability in a given skill (much or very much). Only four items received more than 80% positive responses, suggesting that the respondents rated their desire to grow in ability elements as low since about half of the items in Q1 received more than 80% of positive responses. It is possible that the low rating is due to a lack of motivation to improve on ability elements or that they already rated themselves as having a sufficiently high level of competence in ability elements.

This study targeted first-year university students who are building up their learning at university, including their professional studies. The results of this study are consistent with the results of METI (2010), which reported that while learners have low awareness of social skills, such as those listed as ability elements, companies and other social organizations recognize that they are lacking in college students. Thus, increasing students' STEM competencies is essential for future success in STEM HR, and it is critical to address their development in curricula and educational programs. As mentioned in Horie et al. (2007), it is crucial to be aware of the importance of ability elements and high motivation to learn to enhance the ability. For this reason, correlation analysis was conducted based on the responses to Q1 and Q2 to confirm the perception of learning about ability elements in the first year of university.

Figure 9
Results of learning motivation perceptions (Q2: All respondents)

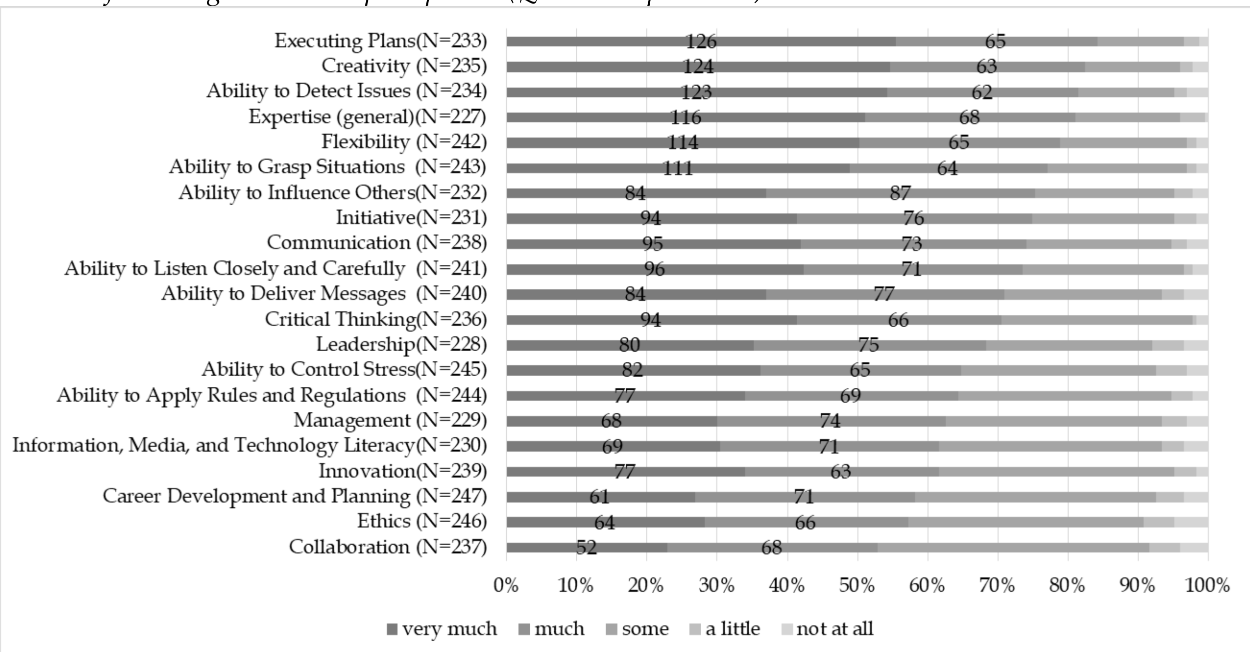

Table 6 presents the correlation analysis findings. In the correlation analysis of the importance of mastering the STEM competencies, all items showed a positive correlation (7 items positive, 14 items weakly positive). In the data on Japanese students, there is a positive correlation between competency elements and motivation for growth, indicating that students themselves want to improve these competency elements in the future.

Table 6
Correlation analysis between perception of importance and learning motivation

	N	r			N	r	
Expertise (general)	226	.269	***	Communication	226	.386	***
Leadership	226	.434	***	Innovation	227	.403	***
Management	227	.414	***	Ability to Deliver Messages	227	.359	***
Information, Media, and Technology Literacy	227	.388	***	Ability to Listen Closely and Carefully	227	.398	***
Initiative	227	.326	***	Flexibility	227	.273	***
Ability to Influence Others	227	.383	***	Ability to Grasp Situations	227	.309	***
Executing Plans	227	.350	***	Ability to Apply Rules and Regulations	227	.486	***
Ability to Detect Issues	227	.298	***	Ability to Control Stress	227	.360	***
Creativity	227	.296	***	Ethics	227	.485	***
Critical Thinking	227	.374	***	Career Development and Planning	227	.553	***
Collaboration	227	.463	***				

Note. ***: $p < .001$

This result differs from METI (2010) finding of low motivation to learn social skills and low importance ratings for both. Students in STEM fields are less motivated to grow in social skills but positively correlate with perceived importance. Although students in STEM fields are less motivated to succeed in social skills, they are positively correlated with their perception of the importance of these skills, suggesting that they have less motivation to learn to increase their ability elements. Horie et al. (2007) states that learning motivation is the foundation of innovation. To increase the ability elements examined in this study, it is crucial to start by changing the students' self-evaluation of ability elements, since they rated the importance of ability elements very high.

4. Conclusions

This study summarized the perceptions of first-year university students studying STEM fields in Japan regarding ability elements as relevant components of STEM competency. The results showed that awareness of importance was very high, with five of the 21 items scoring over 90% and 11 items scoring over 80%. On the other hand, only four things out of 21 had positive responses of 80% or more for learning motivation. In the gender comparison of the perceived importance of ability elements ratings, significant differences were found for four items, and only "Executing Plans" matched the rankings for positive responses. Males believe that it is crucial for STEM HR to take leadership and initiative toward others and control stress well. On the other hand, females emphasize communication skills to cooperate with others and believe that a high sense of ethics is necessary to achieve this. On the other hand, comparisons by major fields of study showed no significant differences among the respondents according to their majors. In other words, although the academic disciplines are different, they can be grouped as STEM fields and can be considered the same cultural sphere. Based on the results of this study, it is possible that developing curricula and educational programs for STEM competencies, including ability elements, with a focus on gender differences, will have a higher educational effect than developing curricula and educational programs based on consideration of each STEM major.

As for learning motivation, although growth motivation was low, as in previous studies (e.g., METI, 2010), it was positively correlated with perceived importance, suggesting that students have low motivation to learn to increase their ability elements. It is possible that these students were a lack of motivation to improve on ability elements or that they already rated themselves as having a sufficiently high level of competence in ability elements; however, all of them are related to the student's self-evaluation, awareness, and perception. Developing of learning motivation of STEM competency is important. Therefore, since they recognize the importance of STEM competency itself, it is possible to create programs that encourage students to change their self-assessment and increase their motivation to learn; it will lead to an increase in the STEM competency of STEM HR community students to a higher level.

4.1. Limitations and Future Research

This study was conducted with a relatively small sample of Japanese university students; a survey with a more significant number of students is needed. Furthermore, it would be valuable to compare these findings with those from other countries to assess whether there are, in fact, cultural impacts on perceptions of STEM and its importance. Because I aimed to construct a competency model applicable across the international STEM HR community, such cross-national comparisons will broaden the model's applicability. In the future, I believe that a competency model that is tailored to the characteristics of the STEM HR community will be eventually extracted.

Note. This study is based on international conference post-proceedings (Kuroda, 2020a; Kuroda, 2021) as well as partly on Kuroda (2020b), which my doctoral thesis, with additions and corrections.

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References

Aikawa, A. (2007). Can international comparison of social skills be possible? In Kikichi, A. (Ed.), *Measure social skills: KiSS-18 handbook* (pp. 166 - 172). Kawashima Shoten.

Basic Act on Science, Technology and Innovation. (2021). *The Basic Act on Science, Technology and Innovation.* Retrieved from https://elaws.e-gov.go.jp/document?lawid=407AC1000000130_20210401_502AC0000000063

Cabinet Office. (2007). *Long-term strategic guidelines "Innovation 25"*. Cabinet Office. Retrieved from https://www.cao.go.jp/innovation/

Cabinet Office. (2016). *The 5th Science and technology basic plan*. Cabinet Office. Retrieved from https://www8.cao.go.jp/cstp/kihonkeikaku/index5.html

Cabinet Office. (2018). *Annual Economic and Fiscal Report as 2018*. Cabinet Office. Retrieved from https://www5.cao.go.jp/j-j/wp/wp-je18/index_pdf.html

Cabinet Office. (2021). *The 6th Science, Technology, and Innovation Basic Plan*. Cabinet Office. Retrieved from https://www8.cao.go.jp/cstp/kihonkeikaku/index6.html

Central Council for Education. (1996). *The Model for Japanese Education in the Perspective of the Twenty-first Century [Report]*. Ministry of Education, Science and Culture. Retrieved from https://www.mext.go.jp/b_menu/shingi/chuuou/toushin/960701.html

Central Council for Education. (2008a). *Improvement such as study instruction points of kindergarten, elementary school, junior high school, high school and special support school* [Report]. MEXT. Retrieved from https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/__icsFiles/afieldfile/2009/05/12/1216828_1.pdf

Central Council for Education. (2008b). *Toward the Construction of Undergraduate Education [Discussion Summary]*. MEXT. Retrieved from https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo4/houkoku/080410.htm

Central Council for Education. (2008c). *Toward the Construction of Undergraduate Education [Report]*. MEXT. Retrieved from https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/1217067.htm

Central Council for Education. (2011). *The future of career and vocational education in schools* [Report]. MEXT. Retrieved from https://www.mext.go.jp/component/b_menu/shingi/toushin/__icsFiles/afieldfile/2011/02/01/1301878_1_1.pdf

Central Council for Education. (2012). *Toward the qualitative change of university education to build a new future ~ To the university that keeps studying lifelong learning and self-thinking ability [Report]*. MEXT. Retrieved from https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/1325047

Central Council for Education. (2014). *Universal reform of high school education, university education and university entrance selection toward realization of a high connection that is suitable for a new era - all young people to bud new dreams and goals, to make them flower in the future* [Report]. MEXT. Retrieved from https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/__icsFiles/afieldfile/2015/01/14/1354191.pdf

Central Council for Education. (2018). *Grand Design for Higher Education toward 2040 [Report]*. MEXT. Retrieved from https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/1411360.htm

Central Council for Education. (2019). *What Graduate Education Should Look Like in 2040 [Discussion Summary]*. MEXT. Retrieved from https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo4/houkoku/1412988.htm

Council on Promotion of Human Resource for Globalization Development. (2011). *An Interim Report of The Council on Promotion of Human Resource for Globalization Development*. Prime Minister of Japan and His Cabinet. Retrieved from https://www.kantei.go.jp/jp/singi/global/1206011interim_report.pdf

Dasgupta, N. & Stout, G. J. (2014). Girls and Women in Science, Technology, Engineering, and Mathematics: STEMing the Tide and Broadening Participation in STEM Careers. *Policy Insights from the Behavioral and Brain Sciences, 1*(1), 21-29. SAGE. https://doi.org/10.1177%2F2372732214549471

Global STEM Alliance. (2016). *STEM education framework*. The New York Academy of Sciences. Retrieved from https://www.nyas.org/media/13051/gsa_stem_education_framework_dec2016.pdf

Horie, T. , Inuzuka, A. & Ikawa, Y. (2007). Relation between Knowledge Contribution and Intrinsic Motivation within An R&D Organization. *Japanese Journal of Administrative Science, 20*(1), 1-12. Japanese Association of Administrative Science. https://doi.org/10.5651/jaas.20.1

International Engineering Alliance. (2013). *Graduate Attributes and Professional Competencies* (Version 3: 21). IEA. Retrieved from https://www.ieagreements.org/assets/Uploads/Documents/Policy/Graduate-Attributes-and-Professional-Competencies.pdf

Iwawaki, C. (2007). *Hiring of new university graduates in Japanese companies The Context of the Competency Concept* [JILPT Discussion Paper Series 07-04]. Japan Institute for Labour Policy and Training. Retrieved from https://www.jil.go.jp/institute/discussion/2007/documetns/07-04.pdf

Japan Institute for Labour Policy and Training. (2005). *Japanese-British Comparison of Higher Education and Human Resource Development : Relation between Recruitment and Training in Companies and University Education, Findings from Company Interviews* [JILPT Research Report No.38]. Japan Institute for Labour Policy and Training. Retrieved from https://www.jil.go.jp/institute/reports/2005/documents/038.pdf

Japan Society for the Promotion of Science. (2015). *For the Sound Development of Science -The Attitude of a Conscientious Scientist-*. JSPS. Author. Retrieved from https://www.jsps.go.jp/j-kousei/data/rinri.pdf

Japan University Accreditation Association. (2020). *Glossary of university evaluation results* [2020 version]. Japan University Accreditation Association. Retrieved from https://www.juaa.or.jp/upload/files/%E5%A4%A7%E5%AD%A6%E8%A9%95%E4%BE%A1%E7%B5%90%E6%9E%9C%E3%81%AE%E7%94%A8%E8%AA%9E%E9%9B%86%EF%BC%882020%E5%B9%B4%E5%BA%A6%E7%89%88%EF%BC%89%E3%83%9A%E3%83%BC%E3%82%B8%E3%81%82%E3%82%8A.pdf

Kato, K. (2011). The creation and confusion of competency concepts in Japan and the United States. In N. Nishiwaki (Ed.), *Research on Human Resource Development in the Age of Organizational Mobility* (pp. 1–23). Nihon University College of Economics, Institute of Business Research.

Kumano, Y. (2013). *Fundamental research on the development for innovation in science education for formatting science & technology governance* [Grant-in-Aid for Scientific Research (B) Research Report, no: 23300283]. JSPS.

Kuroda. T. (2020a). *A study on stem human resources community ability; focus on higher education students in Japan and Africa*. In Levrini, O. & Tasquier, G. (Eds.), Electronic Proceedings of the ESERA 2019 Conference. The beauty and pleasure of understanding: engaging with contemporary challenges through science education, Part 8 (co-ed. Antti Laherto & Eliza Rybska), 943-948. Bologna: ALMA MATER STUDIORUM – University of Bologna. 978-88-945874-0-1978-88-945874-0-1. Retrieved from https://www.esera.org/publications/esera-conference-proceedings/esera-2019

Kuroda. T. (2020b). *Action researches of First Year Experience of the STEM human resource community in Higher Education: An Approach to ensure the capacity building of Key Competencies in the STEM human resource community* [Unpublished doctoral dissertation (13801-1162)]. Graduate School of Science and Technology, Shizuoka University.

Kuroda. T. (2021). *Recognition of STEM human resources community by higher education students in JAPAN and MALAWI*. In D. Anderson, M. Milner-Bolotin, R. Santos, & S. Petrina (Eds.), Proceedings of the 6th International STEM in Education Conference (STEM 2021) (pp.223-228). University of British Columbia. http://hdl.handle.net/10297/00028234

Libertas Consulting. (2018). *Research and Study on Students' Attitudes Toward Supporting Female Students' Career Choices in Science and Engineering*. Cabinet Office.

Makino, M. (2013). Competency development education by stage in Chuo University Faculty of Science and Engineering. *The Japanese journal of nursing science, 38*(7), 34-41.

Minister's Meeting on Human Resource Development for Society. (2018). *Human resource development for Society 5.0 ~ Changes to society, changes to learning*. MEXT. Retrieved from https://www.mext.go.jp/component/a_menu/other/detail/__icsFiles/afieldfile/2018/06/06/1405844_002

Ministry of Economy, Trade and Industry. (2006). *Study group on fundamental competencies for working persons – [Interim Report]*. METI. Retrieved from https://warp.da.ndl.go.jp/info:ndljp/pid/282046/www.meti.go.jp/press/20060208001/shakaijinkisoryoku-honbun-set.pdf

Ministry of Economy, Trade and Industry. (2010). *Survey on understanding university students' views of working people and demonstrating increased awareness of basic skills for working people*. METI. Retrieved from https://warp.ndl.go.jp/info:ndljp/pid/3518969/www.meti.go.jp/policy/kisoryoku/shakaijinkan.pdf

Ministry of Economy, Trade and Industry. (2018). *Study group on strengthening human resources in Japanese Industries [Report]*. METI. Retrieved from https://www.meti.go.jp/report/whitepaper/data/pdf/20180319001_1.pdf

Ministry of Economy, Trade and Industry. (2019). *Guidelines for developing human resources for higher level design*. METI. Retrieved from https://www.meti.go.jp/shingikai/economy/kodo_design/pdf/20190329_02.pdf

Ministry of Education, Culture, Sports, Science, and Technology. (2007). *Basic act on education (revised 2006)*. MEXT. Retrieved from https://warp.ndl.go.jp/info:ndljp/pid/286794/www.mext.go.jp/b_menu/kihon/about/06121913/002.pdf

Ministry of Education, Culture, Sports, Science, and Technology. (2011). *To develop children's communication skills [Deliberation progress report]*. MEXT. Retrieved from https://warp.ndl.go.jp/info:ndljp/pid/8425509/www.mext.go.jp/b_menu/houdou/23/08/__icsFiles/afieldfile/2011/08/30/1310607_2.pdf

Ministry of Education, Culture, Sports, Science, and Technology. (2014). *Explanation of "qualities and abilities required of professional engineers"*. MEXT. Retrieved from https://warp.ndl.go.jp/info:ndljp/pid/11684192/www.mext.go.jp/b_menu/shingi/gijyutu/gijyutu7/011/siryo/__icsFiles/afieldfile/2014/12/16/1353933_5.pdf

National Science Foundation. (2003). *New formulas for America's workforce: Girls in science and engineering*. NSF. (Publication No.03-207).

Ogata, N. (2001). The impact of the competency concept on higher education. *Japanese Journal of Higher Education Research, 4*(0), 71-91.

Organization for Economic Co-operation and Development. (2015). *Skills for social progress: The power of social and emotional skills*. OECD Publishing.

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics.* PCAST. https://files.eric.ed.gov/fulltext/ED541511.pdf

Partnership for 21st Century Skills. (2009). *P21 framework definitions*. Partnership for 21st Century Skills.

Rychen, D. S., & Salganik, L. H. (2003). *Key competencies for a successful life and a well-functioning society*. Hogrefe & Huber Pub.

Santiago, A. (2017). *Focusing on Cultural Competency in STEM Education*. Informal Science. Retrieved from https://www.informalscience.org/sites/default/files/Focusing%20on%20Cultural%20Competence%20in%20STEM%20Education.pdf

Tominaga, Y. (2018a). *How to Improve the Academic Achievement of Boys*. Diamond, Inc.

Tominaga, Y. (2018b). *How to Improve the Academic Achievement of Girls*. Diamond, Inc.

United Nations Educational, Scientific and Cultural Organization. (2019). *Exploring STEM competences for the 21st century*. UNESCO. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000368485

Wieselmann, R. J., Roehrig, H. G. & Kim, N. J. (2020). *Who succeeds in STEM? Elementary girls' attitudes and beliefs about self and STEM. School Science and Mathematics, 120*(5), 297-308. School Science and Mathematics Association. https://doi.org/10.1111/ssm.12407

Yachi, A. (2001). *Validity and reliability of the competency model as a new competency system*. *Business review 11*(1), 49-62. Bunkyo Gakuin University