Possible L2 Selves for Students of Science and Engineering

Glen Hill
Obihiro University of Agriculture and Veterinary Medicine
Joseph Falout
Nihon University
Matthew Apple
Ritsumeikan University

Reference Data:
Hill, G., Falout, J., & Apple, M. (2013). Possible L2 selves for students of science and engineering. In N. Sonda & A. Krause (Eds.), *JALT2012 Conference Proceedings*. Tokyo: JALT.

Reliance on effective use of English for international collaborative endeavors permeates all science and engineering (S&E) fields—domains of research and development and production that hold a key intellectual resource for saving our planet from many problems it is facing. But S&E students in Japan lack motivation to learn English, although they are very much aware that English abilities are valued in scientific communities and will be needed for success in their future careers. Particularly deficient are these students' abilities to imagine themselves using English in the future, a deficiency associated with feelings of present incompetence and incuriosity about making friends in communities that use English. This paper summarizes 3 studies designed to investigate the interplay of psychological factors leading to these motivational deficiencies and offers teachers examples for countering this dilemma in their classrooms.

理工系の分野は、直面している数々の問題から地球を救うために必要な重要な知的資源を有する研究・開発・生産の領域であり、そのすべての分野で、国際的な共同活動のために英語が上手に使用できることが求められている。しかし、日本の理工系の学生は、英語が社会的に重要とされ、将来仕事で成功するために必要であると認識しているものの、それを学ぶ動機づけに欠けている。特に、将来自分自身が英語を使っている姿を想像する能力が不足しており、それは、英語を使う集団と交流を深めるための能力や関心のなさという気持ちに関連する欠乏点となっている。この論文ではこれらの動機づけ不足の背景にある心理的な要因の相互作用を探求した3つの研究をまとめ、教師が教室でこの問題にどのように対処すべきかを議論する。

From a survey of over 17,000 scientists in 16 countries, it was concluded that, "Japan is the most insular country surveyed, exchanging relatively little scientific talent with the rest of the world" (King, 2012, p. 56). Moreover, Japanese universities dropped in the rankings of The Times Higher Education World University Rankings, with its editor being quoted, "There's a sense that Japan is perhaps isolated on the world stage, in terms of international collaboration in research and also in terms of international student recruitment" ("Todai is No. 1," 2012). While many reasons may be found for this apparent isolation, perhaps a proximal cause is a lack of English abilities, something that can be addressed in education for students in science and engineering (S&E) fields so that they may enter the workforce more capable than their predecessors for connecting with the world.

Little research to date has examined L2 motivation of S&E students, despite the importance of long-term motivation for eventual language acquisition (Dörnyei & Ushioda, 2011). The aim of this paper is to begin such an examination by providing a summary of three studies designed to

identify the relationships between various L2 motivational variables influencing S&E students' motivation to learn English.

English Dominance in S&E Study Fields

English is widely accepted today as the language of science. The fact that more nonnative speakers (NNS) than native speakers (NS) use English for scientific communication (Mauranen, 2003) should come as no surprise in today's globalized world. Scientific collaboration has long been known to lead to productivity (Price & Beaver, 1966). In a globalized world, research and development cannot exist without collaborative and cooperative networks (Kuemmerle, 1997). The domination of English (Grabe, 1988), however, has implications for S&E students who experience difficulty communicating in English as their L2.

English Needs in Globalized Industries

Many S&E students in Japan seek out and land jobs at what they see as stable Japanese technology-based companies, but many of these are not Japanese companies. They are multinational corporations, operating globally, in which English plays a key role in information exchange and where many scientists and engineers are employed.

Considering the global influence of multinational corporations, environmental protection, trade agreements, megaprojects, disaster relief, and the research and development behind it all, it is no exaggeration that the motivation of S&E students to learn English is therefore crucial to improving the quality of life on our planet by learning from, collaborating with, and contributing to the wider world. Becoming proficient in English is vital not just for the individual student's professional success, but also for the successful adaptations, adoptions, and affordances of leading-edge science and technologies that support the health and welfare of the global community.

Why, then, do S&E majors fail to show the necessary motivation to learn English? Data comparing attitudes of English and science university majors in Japan (Life, Falout, & Murphey, 2009) indicated that science students did not like speaking English in class as much as English majors, were less comfortable using English outside class, and were less likely to consider their English education as good. Apple, Falout, and Hill (in press) included data (derived from the data set in Falout, Elwood, & Hood, 2009) that indicate Japanese S&E majors are more likely to be at risk of demotivation than other majors. From their experiences prior to university, S&E majors (compared with non-S&E majors) were less likely to have felt rapport with their English teachers, less likely to have enjoyed dissecting grammar and memorizing vocabulary, more likely to have avoided learning English, more likely to have blamed themselves for their mistakes and poor performance, less likely to have valued their English education, and more likely to have thought they had been studying at the wrong course level.

Additionally, S&E majors share a prevalence of instrumental motivation. Examples come from Bangladesh (Rahman, 2005), China (Yu, 2012), Japan (Johnson & Johnson, 2010; Kaneko & Kawaguchi, 2010), Malaysia (Rahman, Rahman, & Subramaniam, 2012), Spain (Bobkina & Fernandez de Caleya Dalmau, 2012), Taiwan (Fan & Feng, 2012), Turkey (Kirkgoz, 2005), and Yemen (Al-Tamimi & Shuib, 2009). This poses a potential stumbling block for entering the global workforce. On the other hand, integrative reasons for learning a foreign language lead to better language performance and longer lasting language motivation (Gardner, Masgoret, & Tremblay, 1999).

Viable Frameworks for L2 Motivation

There are three extant theoretical models of L2 motivation that could explain difficulties S&E students in Japan face when try-

ing to maintain motivation to learn English: the *socioeducational model*, *self-determination theory*, and the *L2 motivational self system*.

Socioeducational Framework

Drawing from studies related to the socioeducational model (Gardner, 1985; Gardner, Tremblay, & Masgoret, 1997), Masgoret and Gardner (2003) conducted a large-scale meta-analysis examining five components of the model: integrativeness, attitudes toward the learning situation, motivation or motivational intensity, integrative orientation, and instrumental orientation. Masgoret and Gardner concluded that all five of these variables correlate positively to L2 achievement for a wide variety of L2s and in many countries. But in an EFL context such as Japan, in which no obvious L2 language community exists with which to identify or integrate (Gardner, 2001), integrativeness may seem to be irrelevant (Ushioda, in press). Therefore, other constructs now describe motivational orientations for learners who seem not to have immediate access to or control of the L2 culture such as *international posture* (Yashima, 2010), which is a kind of readiness for joining L2-speaking *imagined communities* (Norton & McKinney, 2011). Another type of desire to connect to, not integrate with, the greater outside world has been identified as *intercultural friendship* (Yashima, 2002) or similarly what we call in our studies presented below, *international friendship*. The sense of community or desire for friendship may inform not only the sense of an L2 self, but also may be related to a feeling of competence or anxiety toward L2 communication.

Self-Determination Theory

The need for social relatedness especially in Japan shares importance with the need to feel competent within a social community. These needs form the key elements of the *self-determination theory* (SDT) of human motivation: autonomy, relatedness, and competence (Deci & Ryan, 1985). When a sense of belonging to a particular group or community is combined with a feeling of lessened anxiety or nervousness and the sense of perceived competence in using the L2, learners may develop confidence in communicating in their L2. In other words, SDT may help explain whether learners perceive themselves as capable L2 users now, self-beliefs which can have an influence on their development as L2 communicators.

L2 Motivational Self System

A recent model of L2 motivation derived from *possible selves* theory of mainstream psychology (Markus & Nurius, 1986) is the *L2 motivational self system* (Dörnyei, 2009). Possible selves are future self guides that share three components: the person that learners would like to become, might become, and are afraid of becoming. In the mainstream psychology model, the possible selves can be identified as an *ideal self*, a *probable self*, and a *feared self*, respectively, and act as a motivational bridge between self-concept and behavior. Dörnyei's model (Dörnyei & Ushioda, 2011) depicts motivation as guided by three components. The first is the Ideal L2 Self, or the learner as a person who is a fluent L2 speaker. The second is the Ought-to L2 Self, or the learner endeavoring to avoid becoming a negative self-image (e.g., someone who fails English class). The third component is the L2 experience within the immediate learning environment, which most impacts on cognitive processes that lead to behavioral patterns. The Ideal L2 Self is generally seen as the most formative aspect of L2 identity, positively influencing lasting motivation, whereas the Ought-to L2 Self involves avoidance of negative outcomes, such as bad grades, which instead fosters motivation that is short-lived.

Our Studies of Motivation in S&E Students

This paper will attempt to investigate the relationships, patterns, integrations, consistencies, and inconsistencies in S&E students' motivational components to learn EFL. We seek to understand their attitudes, beliefs, and aspirations not only personally but as contributors to a world that needs their ideas, contributions which cannot be made without communicative English abilities. For developing our own structural equation model (SEM), we adopted, adapted, combined, and otherwise revised the motivational components described above in the three frameworks of motivation in a way that we felt related to a motivational interface between classroom EFL learning and real-world use. As we tested and developed the individual questionnaire items and whole model, some factors were dropped or their relationships to each other were revised, which we will describe in part briefly in each summary below. The following three summaries include results from a study concerning technical college students at one school, a follow-up with undergraduate and graduate students at three schools, and a study in progress comprising students from 20 high school, undergraduate, and graduate school institutions across Japan.

Study 1 Summary

The first study (Apple, Falout, & Hill, 2012) examined the L2 motivation of 395 students at one technical college (*kosen*). Participants completed a 45-item questionnaire measuring nine separate hypothetical constructs such as perceived speaking competence, perceptions of supportive social conditions, and the presence of possible selves. Descriptive statistics (Table 1) indicated participants had a moderate desire to communicate in English to meet new people (*International friendship*) and that they perceived the necessity of using English in their career (*Ought-to L2 self*); they had, however, felt discouraged by their English classroom atmosphere (*Classroom atmosphere*), were largely uninterested in English-speaking cultures and associated media (*Interest in English-speaking culture*), and did not perceive themselves as active or capable users of the language (*Perceived speaking competence*).

Table 1. Composite Mean Index Scores of L2 Motivational Factors for Japanese Technical College Students

Factors	*k*	α	*M*	*SD*
Classroom atmosphere	4	.82	2.58	1.44
Speaking anxiety	4	.83	3.60	1.60
Social value of speaking English	4	.69	4.05	1.40
Perceived speaking competence	4	.85	2.86	1.42
Interest in English-speaking culture	4	.75	2.87	1.55
International friendship	8	.92	3.65	1.65
Ideal L2 self	3	.62	3.15	1.38
Probable L2 self	5	.72	3.74	1.47
Ought-to L2 self	4	.61	3.79	1.53

Notes. A Likert scale of 1 = *weak* to 6 = *strong* was used; *k* = number of items; α = Cronbach's alpha; *N* = 395 (adapted and expanded from Apple, Falout, & Hill, 2012).

Data were analyzed for construct validity, then fit to a hypothetical structural equation model postulating relationships and influences among the variables. The final model (Figure 1) demonstrated strong relations among several variables, most notably those leading to Ideal L2 Self (*Classroom atmosphere, Interest in English culture, International friendship*) and Ought-to L2

Self (*Perceived social values, Probable L2 self*). Contrary to expectations, Ought-to L2 Self, rather than Ideal L2 Self, emerged as the final outcome variable.

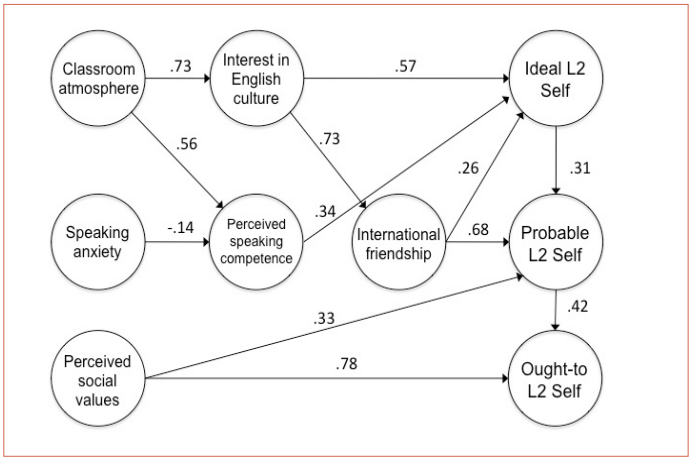

Figure 1. Structural regression model of motivational factors for Japanese technical college students, based on Apple, Falout, and Hill (2012), with the L2 Motivational Self System variables as outcome variables (RMSEA = .07, 95% CI .073-.079). *N* = 395. The strengths of the paths are listed in beta weights (β).

A multiple regression was conducted using the three possible selves variables as independent predictor variables, with English achievement measured by self-reported TOEIC scores as the dependent outcome variable ($n = 317$). Results revealed that Ideal L2 Self predicted TOEIC scores, $F(3,316) = 7.56$, $R^2 = .07$, $p < .001$. Thus, despite Ought-to L2 Self emerging as the strongest motivating factor (Figure 1), students with a stronger sense of Ideal L2 Selves displayed better English abilities.

Study 2 Summary

The second study (Apple, Falout, & Hill, in press) extended the first study by including a larger questionnaire, with 57 items measuring 10 separate constructs, adding *Attitudes toward English* and re-naming *International friendship* as *Desire to speak English*. Study 2 also included a larger sample size to improve external validity, with 654 students from three different institutes, comprising 17 disciplines (Appendix). Construct reliabilities improved slightly from those of Study 1, with reliability estimates ranging from $\alpha = .72$ to $\alpha = .87$. Data were fit to the existing model in Study 1, with the addition of one new construct, *Attitudes toward English* (Figure 2). The results showed the increased influence of the desire to speak or participate in an international community (*International friendship* in Study 1, *Desire to speak English* in Study 2) upon the sense of an Ideal L2 Self ($\beta = .26$ in Study 1, and $\beta = .48$ in Study 2). *Classroom atmosphere* remained a crucial influence on perceptions of speaking competence and maintaining interest in cultural aspects of English. Notably, the Ought-to L2 Self, rather than the Ideal L2 Self, remained the most important Possible Self as the final outcome variable.

As a final analysis, two ANOVA were conducted. In the first, the independent variable was the current year in school of the participant, and the dependent variable was the outcome variable of the model, Ought-to L2 Self. Results showed no significant differences among the groups. The second ANOVA had the same dependent variable, but the independent variable was what final level of education that participants *intended* or *hoped to achieve*. This question split the participants ($N = 517$) into four groups, based on what degree they hoped for: junior college, undergraduate, master's, and doctorate. Significant differences

with a small effect size were found among the four groups, $F(3) = 3.60$, $p = .013$, $\eta^2 = .02$. A post hoc analysis determined which groups were significantly different; depending on whether the final hoped-for degree was a junior college or a master's degree, participants showed significantly different Ought-to L2 Selves with a moderate effect size, $t = -3.45$, $p = .007$, $d = -.38$, $r = -.19$. Thus, rather than the students' *current* year in school, the students' *imagined* or *hoped-for* final goal in educational level was significant in determining their positive sense of possible selves as users of English.

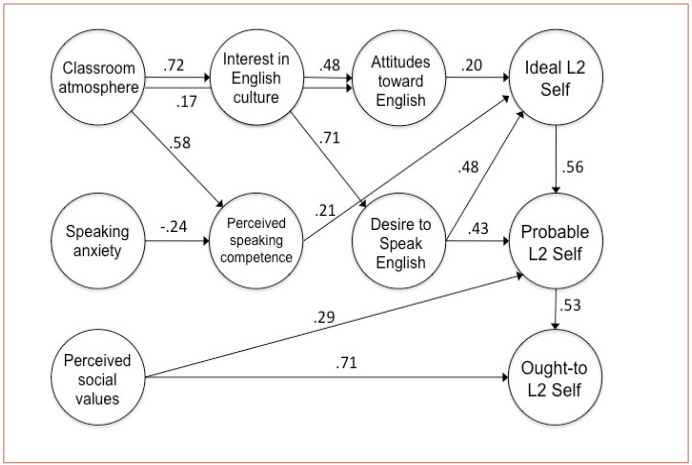

Figure 2. Final structural regression model, based on Apple, Falout, and Hill (in press), with Ought-to L2 Self as the outcome variable (RMSEA = .07, 95% CI .068-.072). $N = 654$.

Study 3 Preliminary Results

In the third study, a questionnaire was created using 53 items based on those from Study 1 and Study 2. Items were revised based on the item reliability analysis from Study 2 in order to achieve greater consistency of reliability estimates across factors. The questionnaire was then piloted ($N = 304$); based on preliminary item and factor analysis, the number of items was further reduced to 48 and the translations of five items were slightly modified. Questionnaires were sent to 20 Japanese institutions with S&E programs. A total of 2,503 responses were collected. Self-reported TOEIC scores from 937 students averaged 385 (low 100, high 980, mode = 350).

The questionnaire represented the first step of a multi-stage project; stages two and three are planned for 2013 and 2014.

Preliminary results (Table 2) indicated agreement with both previous studies. As represented in the sample, S&E students across Japan seemed to overall value learning English (*Perceived social value of English*), desired to communicate in English (*International friendship*), and felt that their future careers depend on their English ability (*Ought-to L2 self*). At the same time, they tended to feel anxious about using English (*Speaking anxiety*), felt that they lacked the competence necessary to communicate (*Perceived speaking competence*), perceived lack of support in the classroom (*Classroom atmosphere*), and had little sense of a future identity as a user of English (*Ideal L2 self*). The differences between the Ideal L2 Self and Ought-to L2 Self of Study 1 and Study 3 are perhaps notable; while the former (*N*-size of 395 at only one school) had a mean value of 3.15 for Ideal L2 Self and 3.79 for Ought-to L2 Self, the latter study (*N*-size of 2,503 students from multiple institutions across Japan) had means of 2.75 for Ideal L2 Self and 4.11 for Ought-to L2 Self. The distance between the image of oneself as an ideal, fluent user of English and as someone who is forced to learn English for material means became more pronounced as we included participants

from a wider range of years in school and from a greater breadth of institutions at more diverse academic rankings.

Table 2. Composite Mean Index Scores of L2 Motivational Factors for S&E Students in Japanese Secondary and Tertiary Institutions

Factors	*k*	α	*M*	*SD*
Classroom atmosphere	5	.82	3.22	1.42
Perceived social value of English	5	.73	4.25	1.35
Speaking anxiety	5	.80	3.83	1.48
Interest in English-speaking culture	5	.78	3.22	1.46
Perceived speaking competence	5	.87	2.80	1.35
International friendship	6	.92	3.82	1.63
Ideal L2 self	5	.87	2.75	1.40
Probable L2 self	5	.72	3.63	1.43
Ought-to L2 self	7	.78	4.11	1.44

Notes. A Likert scale of 1 to 6 was used; k = number of items; α = Cronbach's alpha; N = 2,503.

Results from Study 3 are as yet in the preliminary stage, as we are still collecting and entering data. Further investigation will fit the data to the existing model for confirmation. Our current hypothesis is that the sense of an L2 Self is most affected by classroom experiences and the year in school, particularly near the end of formal education when students start job hunting.

Discussion

Across these three studies it seems that many Japanese S&E students very much believe that social values dictate that they become proficient in English for their own future professional success, seen in the strong influence from social values upon the Ought-to Self. But with moderate interest in making friends in English-speaking cultures and poor perceptions of their English classroom experiences, there seems little in students' academic backgrounds to promote positive self-beliefs as future users of English—beliefs which can become self-fulfilling prophecies. It seems that S&E students may not be receiving an education that helps them to connect the social values of English with their professional and personal identities as users of the language.

As for improving classroom atmosphere, teachers may consider employing metacognitive learning strategies so that students are more conscious of their learning (Hiromori, 2004). Helping students to increase motivation and vision of future L2 self images seems possible through learning activities that can stimulate multiple senses within the imagination, particularly approaches that combine visual and auditory learning styles (Dörnyei & Chan, in press). Munezane (2008) reported increased motivation and English skills, critical creative thinking, and ethical awareness in sophomores majoring in science who designed and presented a dream robot and discussed the civil rights of self-conscious robots, a possible social dilemma in the future. Fukada, Fukuda, Falout, and Murphey (2011) demonstrated measurable gains in motivation and self-reported behaviors to learn English after students interacted with classmates through activities that helped them to share their possible selves, such as compiling a list of dream jobs, attending an imaginary 10-year class reunion, and sharing three possible selves. Sampson (2012) reported raised metacognitive awareness of increased motivation towards English from activities which similarly focused upon sharing possible selves within the classroom, such as predicting one's own and other's futures, imagining situations where lack of English caused trouble, and drawing a timeline to one's ideal future, complete with roadblocks and contingencies.

These studies provide examples to help future scientists and engineers envision using English in their futures.

Making further connections from this paper's experimental data involving Japanese S&E students' EFL motivations to specific implications for the classroom is beyond the scope of the design of these investigations. We would, however, like to offer some ideas of what we think might be helpful to improve S&E students' confidence, interests, and imaginations:

- expose students to real-life Japanese scientists and their career situations to become aware of the true need for English in the workplace and to help visualize the potential successes they can achieve;
- demonstrate that nonnative speakers in S&E fields outnumber the native speakers and that they don't need perfect English to communicate;
- provide lessons with career-related applications, including real-life examples of how Japanese company workers use English in their field;
- create opportunities for communication such as email or Skype exchanges, joint problem solving, school visits for topical discussions, or debates with foreign students in similar fields;
- encourage socially interactive learning (group or pair work, presentations, telephone simulations), not just rote learning and memorization;
- integrate students with different majors to broaden their perspective on science and to encourage learning of overlapping academic vocabulary;
- invite students to explain to peers about their study- or work-abroad experiences; and
- help students early in their academic lives to learn what scientific journals are, since they will be told by science teachers to read them before finishing undergraduate school.

Summary

This paper presented three studies developed in succession to establish a viable structural equation model of Japanese S&E students' motivations to learn English. The aggregated findings indicate that students feel they are not getting enough classroom support upon which to base their confidence as EFL speakers. This in turn has negative motivational consequences in that, by and large, students are unable to envision themselves in the future as competent speakers of English. On the other hand, these same students generally perceive that society requires their English abilities, prompting the motivational drive to avoid failing to become proficient in English. Their visions of different aspects of themselves seem to fall in a divide between Ought-to Self and Ideal Self, and thus their motivation to learn English may sway. We will keep asking what academic experiences might make S&E students aware of their situations as soon-to-be scientists facing problems and making solutions related to the welfare of the world.

Acknowledgements

These studies were partially funded by a grant from the Japan Society for the Promotion of Science, Grant-in-Aid for Scientific Research (C) 24520691, and supported by many of our JALT colleagues to whom we owe much thanks, including Brian Cullen, Michael Faudree, Terry Fellner, Rich Grumbine, Michael Guest, Eric Hagley, Kathy Johnson, Michael Johnson, Jonathan Kay, Tom Koch, Leigh McDowell, Bern Mulvey, Charles Robertson, William Rozycki, and Eric Skier. Gratitude is also extended to Yoshie Hill, Etsuko Shimo, and Mutsumi Shioda for Japanese translations.

Bio Data

Glen Hill is an assistant professor at Obihiro University of Agriculture and Veterinary Medicine, Obihiro, Japan, where he is also the manager of the English Resource Center. He has taught English courses in Japan since 1998 in business English, private high school, and university undergraduate and graduate courses. His research includes extensive reading, scientific writing and presentations, and ESP. He is chief editor for the *OnCUE Journal* and copyeditor for *Scientific Drilling*. <hill@obihiro.ac.jp>

Joseph Falout, an assistant professor at Nihon University, College of Science and Technology, teaches English for academic purposes and English for specific purposes to undergraduate and graduate students. He researches into the social educational psychology of language learning and teaching, with an interest toward pedagogical applications. He edits for the *OnCUE Journal* and the *Asian EFL Journal*.

Matthew Apple is an associate professor of international communication at Ritsumeikan University, Kyoto, Japan. He has taught at various levels of education in Japan since 1999, including junior and senior high school, undergraduate university, and graduate school. His research interests include ESP, individual differences, and second language vocabulary. <mapple@fc.ritsumei.ac.jp>

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Appendix

List of Disciplines of Participants in Study 2

- Mechanical engineering
- Electrical engineering
- System engineering
- Electronics and computer science
- Applied chemistry
- Agriculture
- Architecture
- Civil engineering
- Veterinary science
- Socio-transportation engineering
- Aerospace engineering
- Oceanic architecture
- Precision machinery engineering
- Physics
- Mathematics
- Chemical engineering
- Information science