The Relationship Between Future Career Self Images and English Achievement Test Scores of Japanese STEM Students

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Abstract—Background: College and university science, technology, engineering, and mathematics (STEM) students in Japan, who hope for careers in science and technology fields, lack the motivation to learn English as a second language (L2), impairing their current capacities to learn the L2 and their future abilities to communicate globally once employed. Literature review: Although these students’ motivation to learn English seems strongly linked to the external pressure to do well on a standardized English test, gain employment, and progress up the career ladder, this extrinsic motivation may not be as beneficial for their L2 learning as positive images of themselves using English in future situations. Three types of future career-related self images—an Ideal L2 Self, a Probable L2 Self, and an Ought-to L2 Self—are hypothesized to promote L2 achievement. Research methodology: Data from questionnaires examining psycholinguistic variables for 1013 Japanese STEM students of English were subjected to ANOVA and multiple regression analysis with three L2 Self variables as predictor variables and scores from the TOEIC standardized English exam as the outcome variable. Results/discussion: ANOVA results showed that students had a strong image of themselves as needing English for future career goals, as measured by the Ought-to L2 Self, but had lower levels of Ideal L2 Self, the variable measuring a future image as a fluent user of English. In the regression analysis, the Ought-to L2 Self predicted lower TOEIC exam scores; conversely, the Ideal L2 Self predicted greater TOEIC scores. These paradoxical results indicate that Japanese STEM students struggle motivationally to improve English skills needed for future STEM job-related communication, despite feeling pressured to do so. Conclusions: To encourage the formation of students’ images of Ideal L2 selves or stronger Probable L2 selves, STEM teachers and language teachers of Japanese STEM students could introduce motivational interventions. For example, positive role models of English language learners could visit classes and demonstrate how they have applied their English as a foreign language (EFL) learning experiences to future careers.

Index Terms—English as a foreign language (EFL), future self-images, Japan, possible selves, Test of English for International Communication (TOEIC).

Students in the disciplines of science, technology, engineering, and mathematics (STEM), whose first language (L1) is not English, increasingly feel pressed to improve their English language skills for communicating with team members, supervisors, and outside contractors; in addition, they recognize the need to publish and present their academic research, whether the students are outside Japan [1]–[4] or inside Japan [5]–[15]. The communication problems that Japanese engineering specialists face are exemplified by one study, which investigated business language barriers in a Japanese multinational semiconductor manufacturer in Germany conducting business with seven German companies producing cars or car components, semiconductors, electronics and industrial machinery, or pharmaceuticals [16]. Researchers interviewed factory managers as well as engineers and found that the relatively low spoken English language proficiency of the Japanese contributed to communication problems, resulting in significant delays and higher decision-making costs. Portable translation devices were widely used but considered ineffective, and the use of human translators or interpreters added to operating expenses. Better English
Practitioner Takeaway

- Japanese STEM students in college and university settings realize societal obligations to study English, but they do not feel as strongly about an ideal image of their future selves as English users in the workplace.
- These differences, when applied to a standardized English exam (TOEIC), predicted scores in the opposite direction. An Ought-to image predicted that they would get a lower score, while an Ideal image predicted a higher score.
- The psychological conflicts arising from the images of their future English-using selves promotes motivational problems for studying the language. Suggestions are offered to improve student motivation.

communication skills would undoubtedly have reduced or even eliminated these delays and costs.

Unfortunately, STEM students in Japan for whom English, the lingua franca of science, is a second language (L2) struggle at both recognizing their linguistic limitations and taking action to resolve them [9], [17]. Moreover, STEM students in Japan frequently experience difficulty maintaining their L2 motivation to learn English, a problem that may negatively impact their English ability, thus potentially negatively affecting their future careers and employers [18]. This lack of L2 motivation may result in large part from the historical focus on examinations as the main method of language learning assessment [19]–[21]. However, although Japanese STEM students often feel a pressing need to study for English exams, this type of instrumental or “ought-to” L2 motivation may not always lead to the desired outcome of sufficient English ability to perform well in their future careers. What could help Japanese STEM students improve their L2 motivation and thereby improve their English achievement and proficiency?

One possible solution is suggested by a recent theoretical model of motivation in applied linguistics, the L2 Motivational Self System (L2MSS) [22]. The L2MSS incorporates two of the prominent types of future-self guides—ideal self and ought-to self—originally described in the Possible Selves Theory of mainstream psychology [23]. The L2MSS posits that the ideal L2 self is what most likely predicts L2 achievement; however, the few studies that attempted to connect improving the sense of an L2 self to positive language outcomes have produced mixed results [24]–[26].

This article presents results of a quantitative cross-sectional study of Japanese STEM students that examines to what degree each of three possible L2 selves—ideal, probable, and ought-to—predicts English achievement, as measured by the Test of English for International Communication (TOEIC). The students came from technical colleges (special five-year schools that combine technical high school education and associate degree work), university undergraduate STEM disciplines, and graduate schools of engineering, and each was recruited for the study from within English as a Foreign Language (EFL) courses because of direct relevance of the course content to global scientific communication. What follows is an overview of the Japanese STEM culture, a summary of test-taking culture in Japan, and a description of the L2MSS, including results from its application within the authors’ previous research on EFL motivation of Japanese STEM majors. These will lead into research questions for this article.

Literature Review

International STEM Context The fact that there are at least three times more non-native speakers of English (NNS) than native speakers (NS) should come as no surprise today [27]. However, although the ability to communicate orally is viewed as an essential and even critical component of success today, NNSs in STEM fields sometimes mistakenly think that their technical skills alone will suffice [28], [29]. In their STEM programs, English L2 learners are often faced with speaking tasks for general communication about daily life, and they may occasionally travel abroad or meet people in their own countries and have to deal with the same needs.

Once STEM students leave school and enter the global workforce, their situation could then change to expect them to capably engage in technical terminology, whether in formal presentations or poster sessions (as a presenter or audience
As with NS STEM students, Japanese NNS STEM students face demands on learning relevant technical skills and knowledge, but in Japan, they are further burdened by demands of English language requirements. A survey of 2062 pre-university physical science students in Japan showed that “likely job satisfaction” ranked highest among 25 factors that influence them toward science [45]. However, Japanese STEM students in postsecondary and tertiary schools (technical colleges and universities, respectively) face an English learning dilemma. At universities, Japanese STEM majors attend lectures, gain practical experience in laboratories, go on field trips, write experimental reports, acquire complex descriptive and technical language, and perform research. These STEM-related activities require increased knowledge of academic Japanese and leave little time for English language studies. Moreover, STEM students’ academic workload increases after the first two years of mandatory core courses have been completed, so taking elective English classes is either deemed impractical or ignored [46].

Despite the recognized necessity of English in a globalized economy, a common assumption among prospective engineers in Japan is that they need not study, learn, or use English in their chosen careers once they join the workforce [47]. This is perhaps implied because science departments require English only early on in their undergraduate curricula and provide little emphasis on its importance or relevance to postgraduate STEM-related jobs. However, graduate students in STEM fields may come to realize the value of English. Results from one study showed distinct differences between Japanese students in labs with and without international students [48]. A key point is that the former had more enthusiasm about English education. Japan’s internationalizing of universities seems to equate primarily to adding foreign students, so perhaps this feeling will increase, but it is a passive approach that needs a stronger push. Globalization is forcing the need beyond past expectations when just a few “elite” engineers engaged in English [29]; discussions, negotiations, and management decisions are often required whether engineers work abroad or in Japan [49].

The inadequacy of Japanese STEM students’ language education belies their likely future needs to use English. Although students may aspire to careers in large corporations, a poor foundation in English may have a wide-ranging and unexpected effect even if the employer is not a large one. A 2009 study of 185 small and medium manufacturing companies in Tokyo observed that, “In Japan, small and medium sized enterprises … accounted for 99% of all manufacturing companies and 74% of the workforce in the industry in 2006” [50, p. 1]. Moreover, although the English demands were different depending on how the companies operated, engineers in these companies “often need to perform tasks associated not only with technical matters but also sales and contracting, due to their small number of employees” [50, p. 4]. These common communication activities have been confirmed globally, and related language competencies deemed valuable and necessary include those involving management, teamwork, entrepreneurship, negotiations, and business skills [36], [38], [51].

Incongruently, Japanese STEM students often perceive their English abilities as low, yet they simultaneously believe English to be important. As has been observed, “This contradiction creates a back and forth struggle resulting in a lack of motivation” [52, p. 16]. For instance, Japanese
graduate students and company employees in the computer industry agree on the need for English. However, they typically self-report very weak English language skills, especially for giving presentations and participating in meetings, both of which require complex communication skills [6]. In one case, an overwhelming number of students in Hokkaido University’s English graduate program in socio-environmental engineering reported that English is needed for their research (>70%) and for their careers (>80%), yet 93% still felt they need to improve their language ability [7].

Often, students need international exposure to open their eyes to their weaknesses in communication and motivate them to learn more. When Japanese engineering undergraduates at the University of Aizu contemplated studying abroad, they realized the inadequacy of their language ability, and only those who returned from such an experience appeared to understand the concept of global (cross-cultural) competence in communication [12]. Moreover, even when some Japanese students perceive the need for English ability, they may envision more of a demand for technical language, when, in reality, it might be an even mix with casual conversational English [9].

Difficulties communicating in English experienced by Japanese STEM students and professionals are shared by those in other cultural contexts around the world. Examples are especially prevalent in countries where the native language script does not use Latin characters or where the native language is a non-Indo-European language. STEM students and professionals in these countries (e.g., China, Finland, India, Korea, Russia, Saudi Arabia, and Thailand) recognize the difficulties that they face in English communication yet are often stymied by a lack of institutional support when they are students [53]–[59]. Although L2 STEM students, including those in Japan, acknowledge problems with curricula, ability, and corporate needs, Japanese students face an additional challenge to learning English: their dependency on a specific English exam. This situation is described in the next section.

**Test-Taking Culture in Japan**  Japanese people are accustomed to taking exams to obtain licenses and certificates in many fields. Students commonly sit for exams for entrance into junior and senior high schools, as well as undergraduate and graduate schools, including tests of English. Notably, English has been a major part of the educational examination system for more than 150 years [60]. Overall, Japan administers over 50 English tests for licensing or certification [61]. The test that Japanese university students, including STEM students, most commonly take is the TOEIC.

Since its inception by ETS in 1979, the TOEIC has become the pre-eminent standardized test in Japan [62]. Approximately 2.5 million Japanese take it every year, with a large percentage of test-takers sitting for the exam more than once [63]. The TOEIC was initially designed as a measure of English training in companies, but postsecondary students in Japan today value and take the exam even before they enter the workforce. Significant numbers of undergraduate and graduate schools in Japan use TOEIC scores for placement purposes or course credits (see Table I) [64]–[66].

Despite the growing importance of the TOEIC in Japan overall, STEM majors consistently demonstrate among the lowest average scores through all four years of academic life compared to students with other majors: information science (393 out of a maximum of 990) science/engineering/agriculture (402), commerce/economics/finance (422), sociology (426), law (428), education (430), Japanese language/literature (449), medical pharmacology (462), international relations (465), and English (495) [67].

Companies use TOEIC scores not only as a criterion for hiring new recruits but as benchmarks for promotions, departmental assignments, and overseas postings [68]. Given the pressure to achieve high TOEIC scores, Japanese STEM
students may equate test-taking as the primary—sometimes sole—purpose for English language learning, thus affecting their L2 motivation both positively and negatively.

Previous Research With Japanese STEM Student Motivation  A common theme emerging from studies of Japanese students’ L2 motivation among both STEM and non-STEM majors has been the students’ main focus on developing international friendships, with secondary interests in international careers and engagement with the world outside Japan [69]–[71]. One structural equation model (SEM) study of Japanese STEM students in a technical college setting revealed that although they desire to meet and converse with new people in English and realize the need for using English in the workplace, students also rated their communicative competence as low, felt discouraged by the English classroom environment, were essentially not interested in English-speaking cultures, and did not visualize themselves as users of English [72].

A follow-up SEM study with STEM participants in three different educational levels (technical college, undergraduate university, and graduate school) confirmed the initial model of L2 motivations by using a larger set of questions and a larger sample size ($N = 654$) [18]. Analysis of variance (ANOVA) using current educational level as the independent variable revealed that there were no significant differences overall of possible L2 selves among the students. However, when conducting a follow-up ANOVA using the expected final educational level as the independent variable, statistically significant differences were found for Ought-to L2 Selves, with higher levels of the variable found for students who expected to achieve master’s degrees compared to students who expected lower final degrees. Thus, the higher that students held their imagined or hoped-for educational goals, the greater those aspirations affected their sense of becoming more capable users of English. In other words, students’ desired educational level and not their current level was indicative of their future possible L2 selves.

L2 Motivational Self System  Possible Selves Theory [23] stipulates that an imagined possible future self lives not in the future, but it is deeply tied to a set of presently felt hopes, fears, or fantasies. A future self image is built from an individual’s notions of what he or she would like to become (an Ideal Self), might become (a Probable Self), and is afraid of becoming (a Feared Self). These images then act as a motivational bridge between one’s self concept and motivated behavior in the present to reach a future self goal [73], whatever that goal may be.

The L2MSS derives from Possible Selves Theory and depicts motivation toward learning a language as guided by three components [22]. The first is the Ideal L2 Self, or the image of the learner as a person who is a fluent L2 speaker. The second is the Ought-to L2 Self, which is a positively oriented image of the person whom the learner believes there is an obligation to become (e.g., someone who receives good exam scores) and was included in reaction to a negatively oriented image of a future self that has failed, particularly in the eyes of a society or community [74]. Instead of another future self guide, the third component of the L2MSS is a teleological dimension and more proximally causal: the L2 Experience within the immediate L2 learning environment, which most affects cognitive processes that lead to behavioral patterns [22]. 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 strategies of negative outcomes, such as bad grades, which do not create lasting motivation (see Fig. 1).

For the present study, Ideal L2 Self and Ought-to L2 Self factors were adopted from the L2MSS model of language learning motivation. The L2 Experience has yet to be validated in questionnaire-based research, so the research questions that we used did not involve that component of L2 motivation. However, an additional future self, the Probable L2 Self, was investigated. It was derived from the Probable Self of Possible Selves Theory, but in this case, the Probable L2 Self is concerned specifically with expectations of becoming an L2 user only. It was included in the current study because of its previous validation in L2 motivation research [75] and for its potential to expand and contrast the predictive capabilities of the motivational variables beyond merely Ideal L2 Self and Ought-to L2 Self. For example, some students might simultaneously feel the pressure of an Ought-to Self circumstance, envision themselves achieving an Ideal L2 Self image, and reach for a Probable L2 Self reality.

Research Questions  Previous studies have shown that the Ought-to L2 Self is more salient for Japanese STEM students [18], [72]. However, the L2MSS postulates that the Ideal L2 Self should have the most salient influence on motivational development for language learning
There is presently only one existing quantitative study using L2MSS that convincingly demonstrates that possible L2 selves are related, albeit indirectly, to actual English outcomes such as achievement test scores [26]. However, the study used TOEFL, an exam that engineering students and employees in STEM-related fields in Japan do not generally find a need to take. It also consisted of humanities students as well as STEM students at a single university but did not separate the data according to study major and did not compare students across educational attainment levels or at different institutions. In contrast, the present study aims to determine whether, specifically for STEM students, possible L2 selves can predict English achievement as measured by the TOEIC, which has strong face validity for STEM students and their future employers. We posed the following research questions to be answered through quantitative analysis.

RQ1. What differences exist among L2 motivational variables for Japanese STEM students at three levels of education (technical college, undergraduate, and graduate)?

RQ2. To what degree are Possible L2 Selves related to English achievement for Japanese STEM students?

RQ3. Which of the three Possible L2 Selves (Ideal L2 Self, Probable L2 Self, or Ought-to L2 Self) is the best predictor variable of greater English achievement (on standardized tests, in this case, the TOEIC scores) among Japanese STEM students?

RESEARCH METHODOLOGY

Participants All participants in the present study were STEM students attending English classes at 19 separate institutions of tertiary education in Japan. Participants were informed orally and in writing that participation was voluntary, that their responses would remain anonymous, and that their identities would not be revealed. The present study stems from a larger, multistage project, which was preceded by a questionnaire-based pilot study at one Japanese technical college (N = 395) that validated the questionnaire and SEM model of nine psychological learning variables [72]. In response to the pilot results, the questionnaire and model were further refined at three institutions where the researchers worked (N = 654) [18], [76]. Then, for the larger project, colleagues at 19 institutions were contacted by email, and paper copies of the final questionnaire were delivered by postal mail. From the original dataset of 2503 questionnaires returned, 95 questionnaires were removed due to missing and incomplete responses. As there were too few graduate student participants to create a separate structural equation model, an additional 155 questionnaires were removed, leaving N = 2253 to be utilized in a cross-model validation of psychological variables,
but not English achievement, among technical college and undergraduate students in a previous study [77].

For this study, data were culled from the original dataset \((N = 2408)\) after data screening; however, only data from students who self-reported their TOEIC scores were used to determine the relationship between the three possible L2 selves variables and English achievement. Questionnaires may have lacked this TOEIC information \((n = 1395)\) because students chose not to report their scores, but students may also not have known, recalled, or had access to their own scores. TOEIC score usage differs among colleges and universities in Japan, whether for admission, course streaming, or other uses. Official access to such scores is also highly restricted for reasons of privacy and remains off-limits for the research purposes. Consequently, only questionnaires from study participants who self-reported their TOEIC scores were used, leaving the final participant size for the present study at \(N = 1013\).

These participants represented a wide range of educational levels from the second year of technical college to university sixth year (required for pharmaceutical and veterinary programs) and doctoral level. All majored in STEM disciplines and were in technical college programs \((n = 518)\), undergraduate programs \((n = 402)\), or graduate programs \((n = 93)\).

**MEASUREMENT INSTRUMENTS**

**Motivation Questionnaire** The original questionnaire consisted of 48 items (see Appendix A in the supplementary material) based on previous studies [18], [72]. A Likert-type scale was used with six categories \((1 = \text{“Strongly disagree” to } 6 = \text{“Strongly agree”})\), with no middle or neutral option. Items were created to measure nine psychological variables that we hypothesized influenced Japanese STEM students’ L2 motivation. Returned questionnaires were optically scanned and analyzed using SPSS software. Data screening analysis showed a normal distribution across all items. In the present study, data from the three Possible L2 Selves variables were used (Ideal L2 Self, Probable L2 Self, and Ought-to L2 Self), comprising 17 items. (For details regarding the model’s variables, see [18], [72], [76], and [77]. The present study focuses on the three Possible L2 Selves variables, which were outcome variables of the structural equation model in those studies.)

**TOEIC** English achievement was measured by the TOEIC, which consists of seven sections, four of which measure listening ability and three of which measure reading ability, with a maximum combined score of 990. Since not all students in the study took the TOEIC for their STEM programs, only students who had taken the TOEIC could choose to voluntarily self-report these scores.

**DATA ANALYSIS**

**Analysis of Variance** Differences among the possible L2 selves of the three student populations (technical college, undergraduate, and graduate) in the study were examined using ANOVA. Because multiple analyses were conducted, a Bonferroni adjustment was applied to reduce the possibility of misinterpretation due to Type II error, making \(p < 0.013\).

**Multiple Regression Analysis** The Possible L2 Selves variables for all sample participants were examined to determine which best predicted English language achievement as measured by the TOEIC. After preliminary analysis to check whether the statistical assumptions had been met, a hierarchical multiple regression analysis was conducted, using Ideal L2 Self, Probable L2 Self, and Ought-to L2 Self as independent predictor variables, and the TOEIC scores as the dependent variable. Ideal L2 Self was hypothesized to be the best predictor of the TOEIC scores, followed by Probable L2 Self, and then Ought-to L2 Self.

**RESULTS**

**ANOVA Results** Prior to conducting the multiple regression analysis, descriptive statistics were obtained for the TOEIC scores and for each of the three Possible L2 Selves variables (see Table II). The mean TOEIC score for all study participants was 390 (low 100, high 980, mode = 350, \(SD = 139.36\)). Technical college students scored the lowest on TOEIC, followed by undergraduate students, and then graduate students. Technical college students had the lowest combined mean scores, and graduate students had the highest combined mean scores for all three Possible L2 Selves variables, representing an increase in EFL motivation in relation to the rise in STEM educational levels.

To test whether the three groups of educational levels were significantly different, four separate ANOVAs were conducted for the TOEIC scores and the three Possible L2 Selves variables, with type of
eductional institution as the independent variable. Three of the four comparisons were found significant, with the fourth comparison failing to achieve significance after the Bonferroni adjustment. There was a large effect size for the TOEIC ($\eta^2 = 0.17$) and small effect sizes for the Possible L2 Selves variables [78]. Post-hoc comparisons revealed that differences existed among all three groups of students for TOEIC scores and for Ideal L2 Self. However, there were no significant differences among the technical college and undergraduate students for Probable L2 Self ($p = 0.643$). Comparisons among the groups of Ought-to L2 Self were not found to be significant ($p = 0.025$), indicating that all STEM participants in the study had essentially the same degree of Ought-to L2 Self regardless of educational level.

**Multiple Regression Analysis** To determine the viability of the data for multiple regression analysis, first, a correlational analysis was conducted with the TOEIC scores, Ideal L2 Self, Probable L2 Self, and Ought-to L2 Self aggregate mean scores ($N = 1013$). All three Possible L2 Selves variables were significantly correlated with the TOEIC at $p < 0.001$ (see Table III). Ideal L2 Self had the strongest correlation ($r = 0.37$), and Ought-to L2 Self had the weakest ($r = 0.10$). Ideal L2 Selves and Probable L2 Selves variables correlated very strongly ($r = 0.70$), a possible indication of the violation of multicollinearity. All variables were checked for variable inflation factor (VIF), and no violation of multicollinearity was found (VIF statistics greater than 5 indicate possible violation of multicollinearity—that is, that the variables are so closely correlated that they influence each other significantly. The highest VIF for this multiple regression was 2.119.) No outliers were identified using the Durbin–Watson outlier or Mahalanobis distance analyses; thus, the statistical assumptions for multiple regression were met.

A hierarchical multiple regression analysis was then conducted, with the TOEIC scores as the dependent variable and the three Possible L2 Selves variables as independent variables. Ideal L2 Self was entered first, followed by Probable L2 Self, and then Ought-to L2 Self. The results indicated that all three Possible L2 Selves variables predicted the TOEIC scores, $F(3,1010) = 58.23$, $R^2 = 0.38$, $p = 0.000$ (see Table IV). Ideal L2 Self was the strongest predictor of TOEIC, accounting for 8% of the difference in the TOEIC scores among the study participants. The beta of 0.291 revealed that an increase in Ideal L2 Self of one standard deviation corresponded to an increase of approximately 40 points on the TOEIC (0.291 times the SD of 139.36 for the $N = 1013$ sample). On the other hand, while Ought-to L2 Self also predicted the TOEIC score, it had a negative beta weight of $\beta = -0.108$, indicating

**TABLE II**

<table>
<thead>
<tr>
<th>Population</th>
<th>$M$</th>
<th>$SD$</th>
<th>$F(2,1010)$</th>
<th>$p$-values</th>
<th>$\eta^2_p$</th>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tech. College</td>
<td>344.25</td>
<td>109.28</td>
<td>104.43</td>
<td>0.000</td>
<td>0.17</td>
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<tr>
<td>Undergrad</td>
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<td>140.40</td>
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<td></td>
<td></td>
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<tr>
<td>Grad</td>
<td>530.59</td>
<td>151.60</td>
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</tr>
</tbody>
</table>

**Ideal L2 Self ($k = 5$)**
| Tech. College  | 13.55 | 5.95  |             |            |            |
| Undergrad      | 14.97 | 5.49  |             |            |            |
| Grad           | 17.17 | 5.58  |             |            |            |

**Probable L2 Self ($k = 5$)**
| Tech. College  | 18.74 | 4.89  |             |            |            |
| Undergrad      | 19.13 | 4.71  |             |            |            |
| Grad           | 20.96 | 4.81  |             |            |            |

**Ought-to L2 Self ($k = 7$)**
| Tech. College  | 29.50 | 6.83  |             |            |            |
| Undergrad      | 29.73 | 5.68  |             |            |            |
| Grad           | 31.44 | 6.13  |             |            |            |

*Note: $p$-value $< 0.013$; a Likert scale of 1 to 6 was used for Possible L2 Selves factors; $N = 1013$; technical college, $n = 518$; undergraduate, $n = 402$; graduate, $n = 93$. 

**TABLE III**

<table>
<thead>
<tr>
<th>Factors</th>
<th>TOEIC</th>
<th>IS</th>
<th>PS</th>
<th>OS</th>
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<tbody>
<tr>
<td>TOEIC</td>
<td>–</td>
<td>.37</td>
<td>.31</td>
<td>.10</td>
</tr>
<tr>
<td>Ideal L2 Self (IS)</td>
<td>–</td>
<td>.70</td>
<td>.37</td>
<td></td>
</tr>
<tr>
<td>Probable L2 Self (PS)</td>
<td>–</td>
<td>.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ought-to L2 Self (OS)</td>
<td>–</td>
<td></td>
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</tbody>
</table>

*Note: $N = 1013$; all correlations significant at $p < 0.001$. 

**TABLE IV**

<table>
<thead>
<tr>
<th>Factor</th>
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<th>$SEB$</th>
<th>$T$</th>
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<tbody>
<tr>
<td>Ideal L2 Self</td>
<td>0.283</td>
<td>0.04</td>
<td>7.15*</td>
</tr>
<tr>
<td>Probable L2 Self</td>
<td>0.168</td>
<td>0.05</td>
<td>3.58*</td>
</tr>
<tr>
<td>Ought-to L2 Self</td>
<td>-0.110</td>
<td>0.04</td>
<td>-3.01*</td>
</tr>
</tbody>
</table>

*Note: $R^2 = 0.38$; Adjusted $R^2 = 0.15$; $N = 1013$; $^*p = 0.000$. 

...
that an increase of one standard deviation would result in a **decrease** of 15 points on the TOEIC.

**DISCUSSION**

RQ1, regarding differences in the possible L2 self-motivational variables among the three educational levels in the sample population, was answered by the results of the ANOVA. The results indicated that the Ideal L2 Self, the Probable L2 Self, and the TOEIC scores were significantly different among the three groups of participants, while Ought-to L2 Self was not significantly different. Technical college students had the lowest mean scores on all three Possible L2 Selves variables, with graduate students having the highest mean scores. The differences in Ideal L2 Self and Probable L2 Self among the three groups of participants may also be explained by time-on-task with using English. However, other influences may be present, such as greater exposure to positive role models in their STEM lab mates and professors, who may not only be proficient in English but may be conducting collaborative research with overseas labs or regularly attending and presenting at international conferences.

Technical college and undergraduate students may also have less cumulative experience using English and fewer opportunities for studying alongside more competent English language users, and thus report lower scores on both the Ideal L2 Self and Probable L2 Self variables, compared to graduate school students, despite sharing nearly identical Ought-to L2 Self scores. Technical college students reported the lowest average TOEIC scores, while university graduate students had the highest. The higher TOEIC scores may simply be a function of educational attainment and emotional maturity of the students; that is, after finishing four years of undergraduate work and at least two more years of graduate school, students will have been exposed to more opportunities to acquire English, whether actively or passively. For example, STEM graduate students usually read and write scientific papers, and although they struggle with both activities, they gain repeated exposure to English at high levels of academic use. On the other hand, all three groups had similar scores on the Ought-to L2 Self variable. This can be explained as a result of students’ perceptions of societal expectations as well as the general test-taking culture within which their STEM studies occur.

RQ2 asked to what degree the Possible L2 Selves are related to English achievement, as measured by TOEIC scores. The correlational analysis with the possible L2 selves and the TOEIC answered this question. As expected and as based on the ANOVA results, all three Possible L2 Selves variables correlated with TOEIC; however, the Ought-to L2 Self variable had an extremely weak correlation ($r = 0.10$), while Probable L2 Self ($r = 0.31$) and Ideal L2 Self ($r = 0.37$) had medium-strength correlations. Given the theory behind the L2 Motivational Self-System, which claims that language learners with strong Ideal L2 Selves will ultimately attain greater language proficiency levels, this correlation provides supportive evidence.

RQ3 asked which, if any, of the Possible L2 Selves predicts English achievement, as measured by the TOEIC. For the sample population in this study, the results were clear. All three groups of students displayed quite strong Ought-to L2 Self images, indicating a shared belief that they had an obligation to learn English, either for their degree requirements, for their careers, or for other societal reasons. However, Ought-to L2 Self actually predicted lower TOEIC scores, not higher, with the $\beta$ weight of $-0.108$ indicating a loss of TOEIC score points. Although Probable L2 Self offered a weak prediction of increased English achievement, Ideal L2 Self had the strongest predictive capability of higher TOEIC scores, as seen by a potential for a 40-point increase in scores. Because the majority of the students in this population display relatively high Ought-to L2 Selves but low Ideal L2 Selves, we can say that this mismatch or ambivalence among possible selves in L2 language learning could lead to less-than-ideal achievement in terms of TOEIC scores and actual communicative language use.

**CONCLUSION**

Three research questions posed for this study examined differences among the L2 motivational variables of Possible L2 Selves of Japanese STEM students as related to English achievement as measured by self-reported TOEIC scores. The first question was answered by an ANOVA, which showed that only the Ought-to L2 Self variable was not significantly different among the three educational levels of STEM students: technical college, undergraduate, and graduate students. The second question was answered by the correlational analysis, which demonstrated that all three Possible L2 Selves variables were significantly related to TOEIC. Ought-to L2 Self had an extremely weak correlation, and Ideal L2 Self had the strongest correlation. The third question was answered by the multiple regression analysis,
which showed that the Ought-to L2 Self predicted less English achievement as measured by the TOEIC, while the Ideal L2 Self predicted greater achievement. Thus, the findings from this study support the theoretical relationship of possible L2 selves to language achievement, as proposed in the L2 Motivational Self System model [22].

The findings in this article partially agree with and partially contradict a previous SEM model study, which found that both the Ideal L2 Self and the Ought-to L2 Self variables were indirectly related to positive gains in English achievement as measured by the TOEFL exam [26]. The present study found that the Ought-to L2 Self was directly related to lower L2 learning achievement, as measured by the TOEIC. This difference can be explained by the fact that the 2017 study included data from both humanities and STEM majors, whereas this article focused solely on STEM majors. The 2017 study also included only undergraduate first-year students at a single university, while the present study included students ranging from first-year technical college to doctoral level at 19 separate educational institutions across Japan. A further difference is the use of the TOEFL in the 2017 study, which is used to determine students’ ability to understand academic English situations in a university setting, whereas this article used the TOEIC, which is designed for Japanese corporations and has strong face validity for STEM majors. Thus, we argue that this article has greater external validity and generalizability across STEM education in the Japanese EFL context.

Implications of the Findings Although much remains to be further investigated, we can tentatively draw some implications for STEM students studying English as their L2. Based on the ANOVA results (see Table II), there may be a maturational aspect present across the possible L2 selves as students acquire subsequently higher levels in their education, particularly for the Ideal L2 Self. The younger students, especially those in technical colleges, may lack real-world exposure to English and may not have as clear an outlook on what they will face in their final choice of STEM-related careers. Undergraduate university and graduate school students not only have more language exposure but also a more focused vision on what is needed for their lives beyond school, as borne out by the greater levels of Ideal L2 Self seen in Table II.

In addition, the mismatch among student expectations and motivational outcomes, including evidence in the multiple regression results (see Table IV) that the Ought-to L2 Self does not predict achievement outcomes evenly, suggests there may be qualities of these three possible L2 selves yet unknown. There may also be other types of possible selves that L2 communication studies have not yet investigated. One possibility is the influence of a specific Feared Social L2 Self, a future self who fails during social interaction in the L2. Another possibility is that of a Past L2 Self, the images of one’s past language learning experiences. This construct has been shown not only to be developmental across one semester in Japanese EFL university classrooms, but also to have a strong relationship with a Future L2 Self that corresponds to the Probable L2 Self in the present study [75]. A final new possible L2 self has been described as the Anti-Ought-to L2 Self, which postulates that learners may have an image of a self that resists or even rebels against perceived familial or societal pressure to learn—or not to learn [79].

Results also imply the need for English L2 classroom motivational interventions for Japanese STEM students, particularly for those in early educational stages of development, even as early as secondary school. Such interventions have proven effective in the short term for some engineering students who find it difficult to imagine themselves as future users of English. For example, one recent year-long qualitative action research study conducted with a class of first-year technical college students showed that students had little sense of possible L2 selves, as well as having notably negative past experiences with language learning [80]. Students were given time in class to reflect on images of their possible L2 selves and to share reflections of their past L2 learning experiences with classmates. They were also introduced to near-peer role models [81]—that is, recent technical college graduates who came to class to share their life stories and experiences, such as STEM-related internships and living overseas. Through these activities, a majority of students were able to experience increases in the strength and quality of their Ought-to L2 Self and Ideal L2 Self images, thus increasing their motivations and improving their language learning attitudes in the present.

Limitations and Suggestions for Future Research As the present study was a cross-sectional examination of future career images of STEM students in one specific cultural context, it lacks external generalizability. Although STEM students in other non-English speaking countries...
experience similar difficulties in learning English, there remains a need to conduct wide-scale, comparative studies across educational levels and cultural contexts, particularly in countries where English is not the first language of future STEM professionals. Also, longitudinal studies that follow cohorts of STEM students over a period of time could better investigate any potential developmental nature of L2 Self images, instead of merely cross-sectional, one-time sampling, such as that employed in this article.

The current study does partially fulfill the need for external validity; however, the data were entirely self-reported, a limitation that has not yet been addressed in many similar quantitative studies on possible L2 selves of learners. Rasch analysis in previous related studies, prior to the ANOVA and multiple regression used in this article, did validate the questionnaire items [18], [72]. In addition, there were small effect sizes in this article due to the sample size, a fact that may further limit external generalizability. Therefore, those investigating possible L2 selves as well as L2 communication researchers in other cultural contexts should interpret the results with caution.

Follow-up questionnaires with open-response items, classroom observation in specific learning contexts, and interviews with STEM students would provide qualitative data about individual L2 learning experiences and explain how they help form possible future L2 self images. Future research may investigate the potential interrelated effects of Ideal L2 Self, Ought-to L2 Self, and other motivational variables of possible selves on L2 achievement, utilizing both quantitative and mixed methods analysis techniques.

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REFERENCES


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