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Comparison of Pre-Intervention IDI Results From STEM and Non-STEM Undergraduate Students

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Abstract

The emphasis on intercultural competence is more prevalent in STEM (Science, Technology, Engineering and Mathematics) majors as the world shifts towards a more globalized economy. When entering higher education, students have differing levels of cultural interaction due to varying peer interaction, family experiences, international travel, and social media experiences. The Intercultural Development Inventory (IDI) has been used to develop an understanding of how students view others and the level of skills they have to interact and adapt to other cultures. Using published data focused on pre-intervention assessment, researchers compared it to data obtained from STEM students preparing for an international experience and studies that already exist to learn more about both student populations and to gain an appreciation of their cultural competencies. As institutions look to prepare their students for jobs in a global workplace, an understanding of where STEM students place according to the IDI in comparison to their non-STEM peers may aid educators wishing to focus on developing these skills in their students. The results of the comparison between Purdue STEM students and other non-STEM students showed STEM students fell into more ethnocentric levels of intercultural competence. This may be explained by the traditionally male-dominated nature of STEM majors, as males have been shown to fall in more ethnocentric orientations.

Keywords: global competence, Intercultural Development Inventory, intercultural competence

Introduction

In this global economy, intercultural competence, or the ability to comfortably transition between cultures while appreciating cultural differences, is increasingly important for success in the workplace and in personal life. With the push for STEM (Science, Technology, Engineering and Mathematics) education to prepare students for jobs that are ever more technical, emphasis on the humanities and other cultural experiences, such as study abroad, have taken a backseat to internships and other on-the-job experiences for many students. This may not be the case for non-STEM students, who may be less technically focused, allowing more flexibility to focus on cultural experiences. This paper concerns the differences in STEM students' and non-STEM students'

levels of intercultural competence as measured by the Intercultural Development Inventory (IDI). The results were obtained by comparing IDI results from students from a selection of available literature, including only the pre-intervention assessments. Pre-intervention is defined as IDI assessments taken before intervention programs, such as journaling, pre-departure orientations, or study-abroad, were administered by the researchers from which data were obtained.

Consideration of the differences in terms of intercultural competence between non-STEM and STEM students is important, because it may provide insight into areas that need to be focused on to prepare students for the modern workforce. Thus, this research focused on available studies, and the comparison of the results via meta-analysis to available STEM data provided by STEM faculty involved in study abroad programs and globally focused programs at Purdue University. Since the data available differ by study in terms of how the data were presented and what amount of data was given, using traditional statistical-based comparison was not appropriate, and thus a meta-analysis was used. This comparison is intended to provide a preliminary understanding of STEM students' intercultural competence as compared to their non-STEM peers. Again, it is generally recognized the economy is more global than it has been in the past, necessitating students be able to navigate a variety of cultural barriers. Thus, an understanding of STEM students' levels of intercultural competence provides guidance to researchers when considering students' existing levels of intercultural competence prior to global experiences.

Literature Review

Furthering the understanding of STEM students and the way they perceive other cultures vs. students in non-STEM majors will provide a better understanding of this population. Much work has been undertaken to further understanding of how students perceive and mature through cultural exchange and experiences in another country (Moores & Popadiuk, 2011; Sachdev, 1997). Little research has been conducted on those students who study STEM subjects specifically, thus this study focuses on comparing STEM students to others in order to develop an understanding of the similarities and differences in their perception of others.

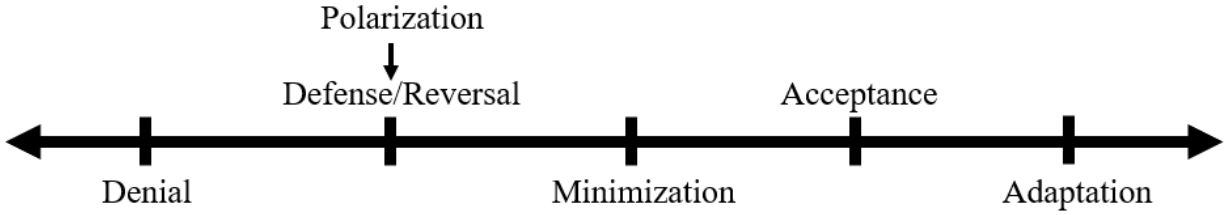
The IDI tool was chosen because there are opportunities to assess the effectiveness of cultural experiences as an intervention. Using a meta-analysis (Borenstein et al., 2009) method provides a summary analysis of available IDI results as provided by faculty involved in providing Purdue's STEM students with an intercultural experience. This systematic approach is generally used to document decisions that are made about the collective articles on the subject (D'Angelo et al., 2014). Replication of the study is possible utilizing this method, and requires the use of research questions to avoid varying replication due to variances in the researcher's intent (D'Angelo et al., 2014). It is anticipated that the result of this study could highlight the gap between STEM students' intercultural competence and the desires of potential employers (Hart Research Associates, 2015). This may provide the impetus for the creation of programs and curricula that support the development of these skills. Studies selected for comparison are discussed in this section, while Purdue data are discussed in the methods section.

What Is the IDI?

The Intercultural Development Inventory (IDI) is a 50-item questionnaire developed by Hammer et al. (2003) that measures intercultural competence. Intercultural competence is the appreciation

of the differences between cultures and the ability to adapt to foreign situations (Anderson & Lawton, 2011). The IDI asks examinees to rate statements concerning intercultural matters on a 5-point Likert scale (Hammer et al., 2003). From these choices, it used the 6-stage Developmental Model of Intercultural Sensitivity (DMIS) developed by Bennett to determine where participants fall on an intercultural development continuum (IDC) (Hammer et al., 2003). Along the IDC are five intercultural orientations: denial, polarization (defense/reversal), minimization, acceptance, and adaptation (Hammer, 2012, 2015). The orientations are shown in Figure 1. The orientations were developed using the DMIS model and these orientations are tested using the IDI. Each of these five stages represent individuals with different levels of intercultural development.

Figure 1. Intercultural Development Continuum (IDC) Used by the Intercultural Development Inventory (IDI)



Individuals falling in denial do not acknowledge cultural differences (Berg et al., 2012). Those falling in polarization tend to see the world in terms of *us* and *them*, either in defense or reversal (Bayl-Smith & Griffin, 2015). Those in Defense believe the culture they identify with is superior, while those in Reversal believe other cultures are superior (Berg et al., 2012). Minimization is next and is characteristic of those who acknowledge cultural differences, but do not fully understand them (Hammer, 2015). Those with an acceptance orientation appreciate both cultural differences and commonalities (Hammer, 2012). The final stage, adaptation, is characteristic of those who can adapt to other cultures both in mindset and in behavior (Hammer, 2015; Hammer et al., 2003). More detailed sources about each orientation can be found in the references.

The IDI measures an individual's Perceived Orientation (PO) and their Developmental Orientation (DO) (Berg et al., 2012). The PO is where an individual believes they fall along the continuum and the DO is a representation of their orientation on the IDC (Hammer, 2012, 2015). From these numbers, an Orientation Gap can be calculated, which is the difference between PO and DO (Hammer, 2012, 2015). It is a way of measuring by how much a person overestimates or underestimates their level of intercultural competence (Hammer, 2012, 2015).

The IDI has been found to be a valid and reliable intercultural development assessment. A study by Paige et al. (2003) involving 378 individuals in foreign language education found the IDI accurately assessed intercultural competency. Finally, according to Bayl-Smith and Griffin (2015), the IDI is not subject to social desirability bias.

Meta-Analysis

The meta-analysis (Borenstein et al., 2009) provides a comparison of data without using significance testing. This is essential when significance testing is not well suited to the data being compared. Due to the differences in type of data, amount of data, and analysis provided in each chosen study, traditional methods of comparison are not adequate for this task. The meta-analysis

allows the comparison of effects across studies and allows collections of research to be compared via quantitative statistics. The data must be comparable when considering the research questions. Beginning with a broad search for research, studies are included or excluded iteratively based on the criteria. This process is continued until data that are adequate and able to address the questions being asked is reached. Little research was found on STEM students, thus the information available for this work was a comparison of STEM research and the available research on students in non-STEM fields.

There was a relatively small number of studies available that met the criteria necessary for this study. However, it has been suggested that completing a *mini-meta* is still valuable when the number of studies is low (Goh et al., 2016). This type of analysis provides a method to summarize data even if it has different sample sizes or other differences (Goh et al., 2016). Therefore, even though a small number of studies were available, the researchers suggest the meta-analysis conducted here was appropriate to provide early insight into the STEM student population.

Chosen Literature for This Study

The systemic review of available literature of studies focused on the IDI pre-intervention scores of DO and was focused on locating articles providing these scores for college students in non-STEM and STEM majors. The resulting articles provided either complete datasets with DO scores or provided the means to determine the size of the population falling in each category along the IDC. The studies chosen for this meta-analysis are described in the following paragraphs. The detailed data available in each study is discussed in each section.

Lokkesmoe et al. (2016). This investigation concerned students in professional management and agricultural science from the U.S. and Brazil who were participating in a semester-long study abroad. The research question was whether a multi-day pre-departure orientation had a significant effect on intercultural development, as measured by the IDI. This study was selected for inclusion because of the provided DO scores for each of the 35 students and its relation to undergraduate students. These students are also non-STEM, providing part of the non-STEM population.

Lantz-Deaton (2017). Researchers here were concerned with campuses that had high percentages of international students. They collected data about the intercultural competence of students in a psychology course at the beginning of the semester. This article provided the percentage of students falling into each orientation and was selected to coincide with the campus environment at Purdue. Purdue has many international students, making the environment of this psychology course likely similar to the environment at Purdue.

Anderson et al. (2006). This study was based on the intercultural development of business administration students after a four-week, faculty-led study abroad. The DO classification of each student was provided for IDI tests administered before departure. The researchers were testing the effects of a short-term study abroad on intercultural sensitivity. The results were included here due to the non-STEM nature of the students involved and provided data. Business administration is less technical than STEM majors, providing a good comparison between groups.

Paige et al. (2004). The researchers created a set of guides to aid students in gaining language skills while abroad. Eighty-six US students in 38 different majors were tested using the IDI before they departed and were provided with the guides. The goal was to test the impact of the guides on intercultural sensitivity and language skills. The article was selected for inclusion because of the pre-intervention information provided. The students could not be clearly classified as STEM or non-STEM from this study, but it provides insight into students at Purdue versus other universities.

Research Questions

The IDI pretest results prior to an actual trip or study abroad experience were considered in this study due to the availability and similarities of available data. The following question was the intent of the research in this project.

> *How do IDI pretest (before intervention) results for Purdue STEM undergraduate students compare to those of non-STEM students from other universities in other published studies, in terms of:*
>
> - *Aggregate means of DO scores*
> - *Distribution of orientations.*

Methods

The researchers selected the IDI for a measurement tool to assess and compare the intercultural competence of STEM and non-STEM undergraduate students. Only the pre-intervention data were considered as the interventions and final data from each of the available studies varied a great deal and did not lend themselves to a one-on-one or aggregate assessment. Since the researchers were only concerned with the intercultural competence of STEM students before they were exposed to study-abroad or other intervention methods, the post-intervention data were neglected by the researchers. These intervention methods differed, and therefore inclusion of the post-intervention data would not provide a reliable comparison between groups.

A systematic review, followed by an extraction of data from each chosen study, was completed for the meta-analysis. Data from Purdue University from 747 STEM students in six different programs were obtained for this analysis. The data featured representation from six different campus groups: three globally focused seminars, a volunteer program, study abroad, and a professional mentoring program. The connection between these groups was that all students involved were interested in developing a global mindset and were STEM majors. STEM majors from Purdue University were considered to be engineering, science, health and human sciences, pre-pharmacy, polytechnic institute majors, and computer science.

A username was assigned to each student to protect anonymity and the students' major, DO, and Orientation Gap scores were analyzed. The data were considered to be pre-intervention data and therefore were compared to the pre-intervention data of other studies. This helped to remove some bias due to differences in intervention types. Sample size varied between data from Purdue University and data from the other studies. These differences are noted below in the demographics table.

The researchers opted to focus on DO as it was DO that provided information on an individual's level of intercultural competence. For each study, tables were created to compare the percentages of each orientation (DO) from each study to data from Purdue University. Differences in percentage were taken with Purdue as the baseline and therefore, a negative sign indicated Purdue University had a higher percentage. Since each study provided data differently, they were organized in approximately the same format. All studies did not provide the same information, so

comparisons were made with what was available. Table 1 was created for quick comparison between the Purdue datasets and the studies in this paper.

Table 1. Demographics Information by Dataset

Dataset	Location	Major(s)	Level	Sample Size *(n)*
Purdue University (STEM)	USA	STEM	Undergraduates	747
Lokkesmoe et al.	USA and Brazil	Business Administration & Agriculture	Rising Seniors/beginning Graduates	35
Lantz-Deaton	England	Psychology course	Freshmen	122
Anderson et al.	USA	Business Administration	Seniors	23
Paige et al.	USA	Mixture	Sophomores/Juniors	86

Findings

First, a direct comparison of Purdue STEM data to each individual article is presented in order to show merit for the conclusions presented later. Next, the Purdue STEM students are compared to the entire grouping of non-STEM students from all articles considered for the overall comparison of STEM versus non-STEM, the meta-analysis portion.

The *Lokkesmoe et al.* study was concerned about the effect of a semester-long foreign immersion program. Purdue University data from STEM students were compared with data from the Lokkesmoe et al. study's pre-departure orientation as shown in Figure 2. Percentage comparisons are presented in Table 2.

Figure 2. Developmental Orientation (DO) Comparison of Lokkesmoe et al. and Purdue STEM Data

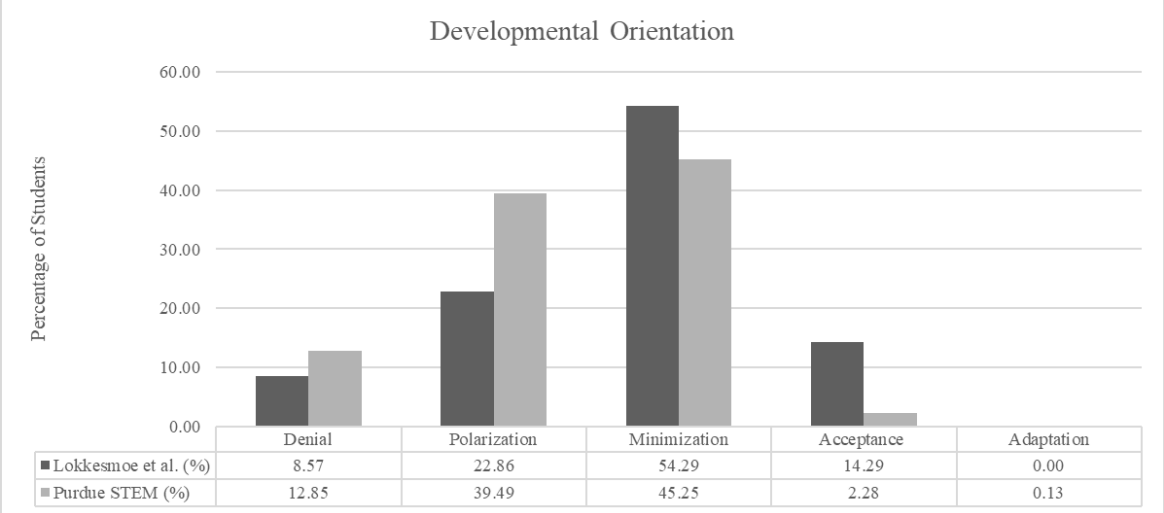


Table 2. Percentage Comparison of Lokkesmoe et al. and Purdue STEM Data

Comparison	Denial (%)	Polarization (%)	Minimization (%)	Acceptance (%)	Adaptation (%)
Lok. - Total	-4.28	-16.63	9.04	12.01	-0.13

From Figure 2, it was observed that Purdue University's STEM group has a higher level of polarization and a lower level of minimization than the Lokkesmoe et al. data. Both datasets indicated students falling in the more ethnocentric orientation levels.

Another study by *Lantz-Deaton* focused on 'internationally diverse home campuses' and students' abilities to mix with the different cultures on campus. Data were collected at the beginning of the semester, and these data were used for comparison in this paper. Figure 3 and Table 3 present similar information contained in the previous figure and table for the Lantz-Deaton data.

Figure 3. Developmental Orientation (DO) Comparison of Lantz-Deaton and Purdue STEM

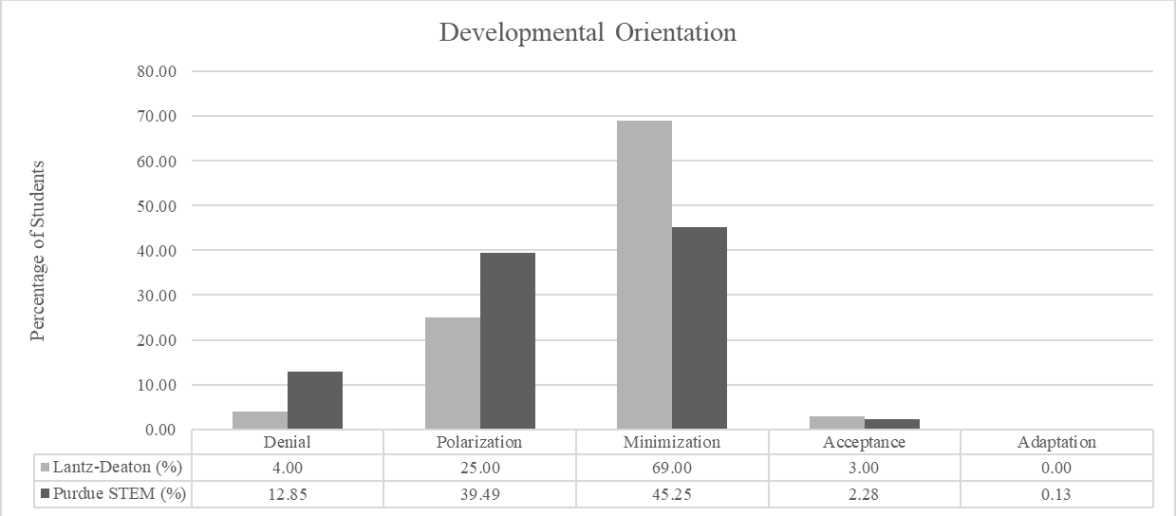


Table 3. Percentage Comparison of Lantz-Deaton and Purdue STEM Data

Comparison	Denial (%)	Polarization (%)	Minimization (%)	Acceptance (%)	Adaptation (%)
Lantz-Total	-8.85	-14.49	23.75	0.72	-0.13

Figure 3 shows the Purdue STEM students were split almost evenly between polarization and minimization for their DO, while the Lantz-Deaton students tended to fall in minimization more often than the Purdue STEM students.

Anderson et al. concentrated on a faculty-led, short-term study abroad. Comparisons using the DO from pre-departure data on the IDI are shown in Figure 4 and Table 4.

Figure 4. Developmental Orientation (DO) Comparison of Anderson et al. and Purdue STEM Data

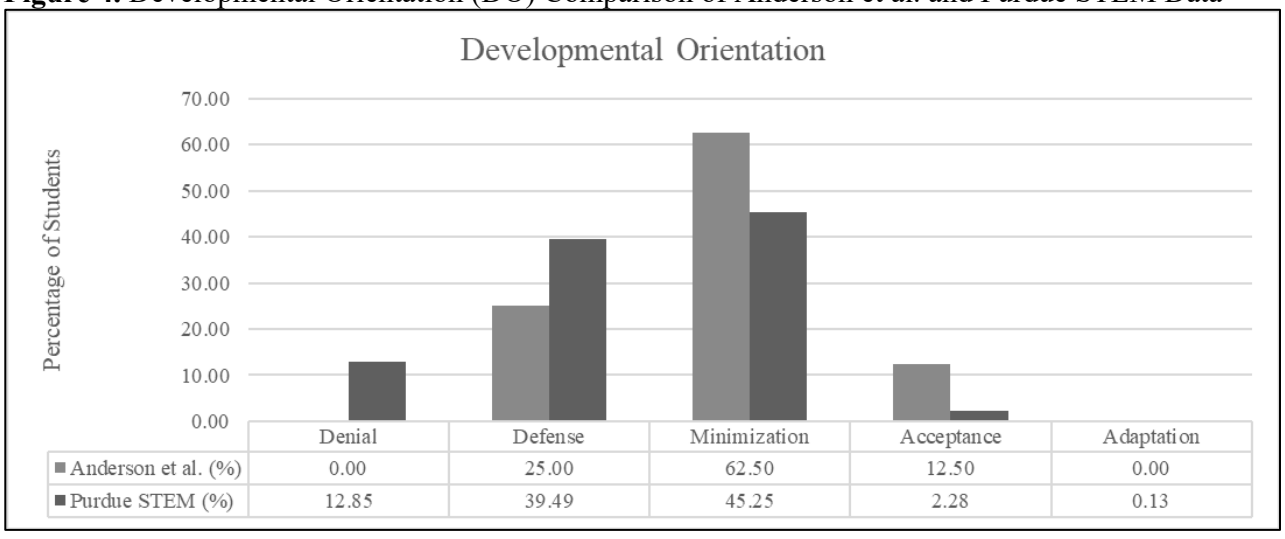


Table 4. Percentage Comparison of Developmental Orientation (DO) for Anderson et al. and Purdue STEM Data

Comparison	Denial (%)	Defense (%)	Minimization (%)	Acceptance (%)	Adaptation (%)
Anderson et al.–Total	-12.85	-14.49	17.25	10.22	-0.13

The Anderson et al. dataset has a higher percentage of students falling in Acceptance and Minimization than the Purdue STEM dataset, as shown in Figure 4 and Table 4. Therefore, the Anderson et al. students have a slightly more ethno-relative worldview on average than the STEM students.

Finally, the *Paige et al.* study (2004) was evaluating a set of *guides* for students on study abroad experience. The authors were testing the effect of these guides on students' development of intercultural competence. Only average DO pre-intervention scores were provided by this study, so Purdue University STEM averages were calculated for comparison. The average Paige et al. student had an average DO of 99.07, falling in Minimization while the average Purdue STEM student had a DO of 85.52, also falling in Minimization.

While the average Purdue STEM score and the average Paige et al. score both fall in minimization, the Paige et al. score is slightly higher with about a 14-point difference. Therefore, on average, the students in the Paige et al. study were at a slightly more ethno-relative level of intercultural competence than the average Purdue STEM student.

Comparison of STEM vs. non-STEM Student IDI Performance

To further compare the data from the STEM students vs. the non-STEM students, a z-test using proportions was run between the different datasets. The percentage of students from each of the STEM and non-STEM categories were noted and the inferential statistics run on the data. Using a significance level of .01, resulting in a confidence level of 99%, the researchers compared the percentages of non-STEM and STEM students falling in each orientation. The results of this analysis are provided in Table 5.

Table 5. Purdue STEM vs Non-STEM (Lokkesmoe et al., Lantz-Deaton, Anderson et al.) Statistics by Developmental Orientation (DO)

Category	STEM (%)	Non-STEM (%)	Left-tailed z_c value	z	Significance Level (Pearson's)	Effect Size (80%)
Denial	12.851	4.046	-2.33	3.310	0.9995	229
Polarization	39.491	24.277	-2.33	3.743	0.9999	214
Minimization	45.248	65.318	-2.33	-4.758	0	138
Acceptance	2.276	6.359	-2.33	-2.817	0.0024	573
Adaptation	0.134	0	-2.33	0.482	0.6849	8704

$p < .01$

Since it is easier to compare the number of students falling in each orientation along the IDC as proportions, a z test was run to determine if statistical differences existed between the STEM (Purdue) and non-STEM (Lantz-Deaton, Anderson et al., Lokkesome at al.) student groups. The null hypothesis was taken to be that on average, STEM students and non-STEM students would not differ in their levels of intercultural competence as measured by the IDI. The not null hypothesis was that STEM students would be less proficient in intercultural competence than their non-STEM peers, a hypothesis made after preliminary observations. The effect size necessary assuming a power of 80% is provided in the last column. The null hypothesis could not be rejected

for denial, polarization, or adaptation. However, the null hypothesis could be rejected for minimization and acceptance. This indicates that fewer STEM students rank in minimization and acceptance for DO than non-STEM students. This result could indicate non-STEM students are more ethno-relative in their view of the world pre-intervention than STEM students. However, more analysis is required to confirm this observation.

Conclusions

After comparison with the above studies, the tendency for Purdue University STEM students to fall in more ethnocentric levels of intercultural competence with respect to the other studies analyzed was noted. It follows that the reasoning for the trend needs to be identified. Statistics suggest there is merit to this claim. A limitation of this conclusion was few studies were available for inclusion, as studies of strictly STEM students (or of strictly non-STEM) are not widely available. Further, the studies used for comparison differed in sample size and premise. Thus, the researchers emphasize these are preliminary results only and suggest more work is needed to fully understand the apparent differences in intercultural competence between the two groups.

While evaluating the data, it was noted that the students in the Purdue STEM group significantly fell below their non-STEM peers in other studies in their level of intercultural competence. This was supported by using a proportions statistic z test with resulting p values less than .01. More research is needed to understand the factors behind this apparent trend.

It should be noted that Purdue University is a land-grant university located in the Midwest; this suggests students attending the university are generally from Indiana and may not have experienced as much cultural diversity as students from other parts of the United States. Generally, people from the coasts may have had more experience developing intercultural competencies, suggesting that further study in this area is warranted. The demographics of Purdue University indicate they have the fourth highest international student population in the country. However, students attending the university may not have had experience with people from different cultures prior to enrolling in the university. It should be noted that information regarding university location, gender of students, and specific fields of study were not able to be fully considered as this information was not available from the comparison studies. A future study that considers the effects of these variables would be beneficial to the community's understanding.

Finally, when examining the demographics of STEM students (Lucietto, 2017; Shrestha, 2011), it is inherently obvious that there are more males in these majors. Therefore, the differences noted in DO between non-STEM and STEM majors may be related to increased numbers of males in STEM. It has been found that male students place in more ethnocentric intercultural DO levels than their female peers (Altshuler et al., 2003; Tompkins et al., 2017). This may be related to the phenomenon of categorical perception. Categorical perception is the idea that people group certain things together instead of viewing them as a continuum and is suggested to be a result of one's culture (Timeo et al., 2016). The more time spent in a single culture, the more perception is affected (Hugenberg et al., 2010). Thus, males in STEM may be influenced by cultural specificity through spending time among other STEM males, causing them to create a *system* to measure and categorize cultures.

Reflecting on the original question of the differences of Purdue STEM undergraduate students vs non-STEM students from other institutions, this study provides evidence STEM students may not be as advanced in their level of intercultural competence. They may be romanticizing other cultures and potential study abroad experiences, placing them into the Reversal category of Polarization. This may also be attributed to the location and general experiences of the student population or because the majority of the STEM students are male and tend to be very concrete in the way they view their personal circumstances and the world around them. Further, STEM students may not have the time in their course schedule or the interest in pursuing cultural courses or experiences, further disadvantaging this group from developing their intercultural competence. Although this study is specific to Purdue University STEM students, the group is varied in their backgrounds and culture, with large numbers of international and out-of-state students. However, replication of this type of study at other universities would increase knowledge of the STEM student population as it compares to its non-STEM peers.

Theoretical Implications

The results of this work may be useful for researchers concerned with global education. The lower levels of intercultural competence among STEM students, with the high percentage of males in this field, provides support for the claim that all males tend to have lower levels of intercultural competence. This work suggests STEM students need assistance in developing their intercultural competence, especially in the global economy. Thus, a change in educational practice is needed to emphasize the importance of intercultural competence for STEM students. Some work does suggest there has been an increase in emphasis on courses in cultural diversity in past years among engineering students, but more work is still needed (Chaudhury et al., 2019).

Practical Implications

The results of this work encourage an immediate increase of the teaching of intercultural competence to STEM students. This means that STEM curricula should be altered to encourage the development of intercultural competence, either through study abroad or other intercultural experiences such as international pen pals, which have shown to improve intercultural competence (Jackson, 2008; Lin, 2018) or conversations with students from different backgrounds to share experiences. This is necessary in order to fully prepare STEM majors for the global economy they will enter post-graduation.

Future Research

The understanding of STEM students' intercultural competence versus their non-STEM peers can be increased by future work concerning these students. This future work can address the apparent connection between gender and intercultural competence among STEM students as well as the reasoning behind the statistically significant result of STEM students falling below their non-STEM peers in intercultural competence. Ideally, this future work will suggest a way to improve STEM students' intercultural competence to aid them as they transition into the global economy.

Limitations

While this study is confronted by limitations, it provides a view into an area not yet explored. Researchers were limited in the availability of data separated by major. In addition, since data were

collected from existing publications, unpublished data could not be considered. The results were also reliant upon the accuracy of the data published in the articles used for comparison and the information provided concerning demographics of the sample published in the studies. More STEM and non-STEM student data would have been helpful, as would complete datasets. This meta-analysis used available data and obtained STEM data from sources within Purdue University, providing a comparison that is relevant and helpful to those working with these students in preparation for study abroad experiences.

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