Original Research Paper

Supplementing STEM Career Mentoring Through Biweekly Opportunity Emails

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Abstract: West Virginia University (WVU) is a large R1 land grant institution with a multitude of STEM majors that includes students from underrepresented demographics (e.g., rural, low-income/Pell grant eligible, first-generation, etc.). Though STEM students are supported by dedicated disciplinary advisors, these advisors meet with large numbers of students and may need to limit their discussions to academic scheduling and financial aid. To broaden students' connections and belonging to STEM and to provide underrepresented STEM students with ongoing career mentoring, we initiated an institutional change project involving the distribution of biweekly opportunity emails (fall 2022 - spring 2025). Opportunity emails included listings, links, and deadlines for paid summer undergraduate research at national labs and institutions, and abstract submissions for institutional, statewide and national symposia. At several points, a survey was sent to collect information from recipients on their self-reported impressions and perceived usefulness of the biweekly emails. Survey respondents indicated that on average they read/skimmed 79% of the emails and acted on information 1.7 times during an academic semester. In addition, respondents indicated that the emails assisted them in career planning and made them more positive toward majoring in STEM by influencing their sense of acceptance and belonging at college. The nature of this change work was informed by and documented as a Plan-Do-Study-Act cycle, a quasi-experimental method for effecting quality improvements. The progression of opportunity emails from basic to professional formatting is discussed along with aggregate responses from the surveys.

Keywords: Plan-Do-Study-Act (PDSA); Institutional Change; Career Mentoring; STEM

Introduction

Rural, first-generation, and otherwise underrepresented STEM students face unique challenges in higher education that arise from a lack of parental, financial, and peer support (Stebleton & Soria, 2023). Though all students are paired with an academic advisor upon arrival to college, faculty at larger institutions are often unable to provide extensive individualized support for their mentees (Atkins et al., 2020; Kim, 2009). As a result, disadvantaged students can feel a lack of belonging in their majors and in college, and to the greater scientific community. Not only does this perpetuate feelings of frustration, but it can result in a tangible decrease of undergraduate student persistence in their fields of study (Ahmed et al., 2021; Stebleton & Soria, 2023). Thus, it is important to supply underrepresented STEM students with resources to connect them to the larger academic community at their institution and beyond. Moreover, as elucidated by the American Association for the Advancement of Science (AAAS), belongingness may serve as a key indicator of academic connection and

subsequent persistence of students in STEM (Hausmann et al., 2007).

Our institution is one where large class sizes (especially in first- and second-year STEM courses) may negatively impact faculty-student connection and, thus, students' feelings of belonging to the undergraduate STEM community (Ballen et al., 2018; Cuseo, 2007; Kara et al., 2021). To bridge this disparity, we implemented a change project involving frequent communication with first-generation and other underrepresented STEM students. From fall 2022 to present, the authors, who were associated with the First2 Network at our institution, sent biweekly emails, each email containing a listing of academic, career, and extracurricular opportunities. Emails are an efficient and practical way to disseminate information to a diverse group of students, and most prefer this medium (Shaw et al., 2023).

The opportunity email project was crafted and studied as an institutional change idea under the Plan-Do-Study-Act (PDSA) cycle format. The PDSA method is used widely in business (Marrs, 2019; Moen & Norman, 2006) and healthcare (Taylor, et al., 2013; England, 2021) settings to rapidly enact quality improvements as informed by PDSA quasi-experimental methodology. Most PDSAs focus on small incremental adjustments that potentially impact the quality of experiences for a given population. The PDSA process is iterative and allows for successive improvements based on previous PDSA results.

With this method, an idea is planned ("Plan"), run ("Do"), and the data studied ("Study"). Then, a decision ("Act") is made about whether to keep (with or without modifications) or abandon the idea. PDSA information is documented in a pre-designed template for future reference or in the case that another organization seeks to replicate the change idea.

We planned the biweekly opportunity emails with the intention to inform students of enhancing opportunities such as internships, research apprenticeships, and on-campus communities/events. The objectives of our change idea were that:

- *underrepresented students would receive the opportunity emails and use them (open, read/skim, act on).*
- *recipients would perceive better outcomes related to STEM, and improved ability to identify enhancing activities (e.g., resources, engage in career planning, increase involvement, and find opportunities).*
- *recipients would feel increased belongingness on campus or within their major when receiving biweekly opportunity emails.*

Post-surveys were used to assess the objectives and to collect recipient perceptions (i) to improve the emails and gauge their usefulness ("Study") and (ii) to determine follow-up actions ("Act") of adapting or abandoning the biweekly opportunity email change idea.

Materials and Methods

Participants

The two different groups of undergraduates who will be discussed and referred to in this article are defined below.

Group A: From fall 2022 to spring 2025, all undergraduates who were supported or funded by the First2 Network at our institution (freshmen through seniors) were added as listserv members with their emails and names input into the free listserv system provided by our institution. This included approximately 100 STEM and STEM adjacent majors per year (300 in total) who were then impacted by the change work described herein.

Group B: In late fall 2024, the free institutional listserv for delivery of biweekly, basic (plain-text, generally unformatted) opportunity emails was replaced by a professional third-party email delivery platform (Mailchimp) that allowed formatting, colored regions, and branding, in addition to, assessment and tracking to determine use statistics. At the same time, the recipient list was expanded (to 3,000+) to include all current students who were underrepresented in STEM (e.g., first-generation, low-income/PELL or work-study eligible, rural permanent resident, etc.).

Design

Opportunity emails were sent every other week (biweekly) during each academic semester from fall 2022 to spring 2025. The authors collected and collated opportunities from internal, institutional offices and from external entities (e.g., other institutions, government labs, and industry). Application deadlines were highlighted, and opportunities were ordered by application due date and/or the date of the event. Opportunities that were beyond their due date or event date were removed and new opportunities were added. A sampling of opportunities advertised in the biweekly opportunity emails in the past year is provided below.

- Get involved in research via WVU's Research Apprenticeship Program (RAP)
- Find on campus jobs using WVU Handshake
- Attend tutoring at the STEM Learning Center
- Visit the WVU REACH Center
- Apply for the U.S. Military Health Professions Scholarship (to fund health professional school)
- Apply for paid summer research at the National Institute of Standards and

Technology (NIST)
- Search the nationwide database of NSF-funded Research Experiences for Undergraduate (REU) sites
- Submit an abstract to present research at the WV Undergraduate Research Day at the Capitol (URDC) event

Recipients were automatically added to the email list, but recipients could remove themselves from the list or could ask to be removed. Over the last three years, only a handful of students (5-10) have asked to be removed from the email list.

Prior to carrying out this project, the protocol was submitted to our Institutional Review Board (IRB). The protocol was approved as a FLEX human subjects research protocol (Protocol # 2211678592).

Measures

At the completion of the fall 2022, 2023 and 2024 semesters, we used a Qualtrics delivered survey to assess Group A recipients' perceptions of the biweekly, opportunity emails. For fall 2024, we confined the assessment survey to the First2-funded students (~100) because (i) we wanted students to provide feedback comparing the basic, plain-text emails to the professional, third-party delivered emails and (ii) by that time the expanded list of recipients (Group B) had only received two opportunity emails.

The survey included questions on recipient use of information in opportunity emails (see Table 1) and asked the following - *Approximately, how many times did you*:
- read or skim the information in the biweekly opportunity emails
- find information of interest to you
- act on the information

The survey included Likert statements on perceived outcomes from receiving and reviewing the biweekly opportunity emails (Table 2). A three-point scale was used (3=Agree, 2=Neither Agree nor Disagree, and 1=Agree) for outcome statements.

The survey also included Likert statements on perceived STEM belonging (Table 3) as informed by a survey published by Good, Rattan, and Dweck (2012). A five-point scale was used (5=Strongly Agree, 4=Somewhat Agree, 3=Neither Agree nor Disagree, 2=Somewhat Disagree, and 1=Disagree) for belonging statements. Five Likert statements were used to measure students' self-report *Belonging to the STEM Community*. Responses to these five statements (on STEM acceptance, fit, comfort, respect, and belonging) were averaged to give a STEM belongingness subscale mean. A similar set of five Likert statements were used to measure students' self-report *Belonging in Science and Math Classes*. Responses to these five statements were averaged to give a science and math class belongingness subscale mean. The two subscales were combined to provide a mean score for overall belonging in STEM.

Open-ended questions asked recipients to discuss the most interesting/useful information and recommendations for continuing and improving the emails. One additional question, included in fall 2024, asked recipients to compare the basic and professional delivery platforms.

Analysis

Qualtrics survey results from fall 2022, fall 2023 and fall 2024 (Group A) were combined for this analysis. We used standard statistical techniques to calculate means for Likert questions so that we could review trends in the data.

Data analytics from the professional, third-party email delivery platform were used to determine the number and percentage of Group B students who opened the emails and/or clicked on a link. The number of clicks per link can be used to provide information on the value of the information provided.

PDSA Use

The First2 Network provided PDSA template was used to document the opportunity email project. For the "Plan" stage, this template required input of "drivers", timeline, description of change idea, learning questions, and their predictions, and discussion of logistics for change idea implementation and data collection. Drivers are influential forces that support institutional quality improvement and guide the proposed change efforts. For this project, the primary driver was "*STEM students are meaningfully connected with faculty, staff, and peers in ways that promote belonging (fit), wellness, resilience, and financial stability*." The "Do" stage required input of what occurred when running the change idea and collecting the data. The "Study" stage required input of observations and data interpretations as well as comparison to predictions and key learnings from the project. The Act stage required a recommendation for the next iteration – Adapt (as is), Adopt (modify), or Abandon (don't run again).

Results and Discussion

From late fall 2024 to spring 2025, well over 3,000 students were recipients on the Group B expanded list and received biweekly opportunity emails. The expanded list was 51% female and 49% male students with the majority in the range of 18-24 years of age. In addition, approximately 29% (n = 1056) identified as first-generation (i.e., neither parent earned a four-year college degree) and 72% as rural permanent residents

of West Virginia. Due to university and state policy, exact information about socioeconomic status and related financial aid eligibility cannot be shared.

Overall, a total of 31 Group A recipients completed the Qualtrics assessment survey providing feedback to improve the emails. Although the survey response rate (31 out of about 300 students over three years) was low, anecdotal conversations with recipients indicated that they were very appreciative of this simple method of connecting them with enhancing opportunities and keeping them updated on application due dates and event dates. Survey responses were anonymous (identifying information beyond progress in college was not collected).

Use

The analysis below focuses on aggregate Group A survey responses from fall 2022-fall 2024. As shown in Table 1, our response rate was low (~10-11% avg. response rate per semester) with 31 total responses from students who received the emails and responded to the end-of-semester survey. Survey respondents indicated that on average they read/skimmed 79% of the biweekly emails that were sent. In addition, respondents self-reported finding information of interest an average of 4.0 times and acting on that information (e.g., applied for a program, visited a website, submitted an abstract) an average of 1.7 times during the semester. Respondents indicated various opportunities of interest including on-campus jobs, internships, scholarships, programs that help with medical school, trips to manufacturing sites in WV, and research opportunities. As aligned with the work of Shaw et al. (2023), we found email to be a sufficient method for communicating opportunities to students.

Table 1. Mean Group A student responses (fall 2022, fall 2023, and fall 2024) on use of information in biweekly opportunity emails.

Question **Approximately, how many times did you:**	Mean Response (N = 31)
read or skim the WVU-First2 Network Undergraduate biweekly opportunity emails?	22/28 (79%)
find information of interest to you in the biweekly emails?	4.0
act on the information (e.g., apply for a program, visit a website, submit an abstract, get a free book, etc.) provided in the biweekly emails?	1.7

As shown in Table 2, Group A respondents did perceive a greater connection to the WVU-First2 Institutional Team (mean of 2.4 of 3 agree) and perceived the emails as helping them to identify resources for college success (2.7/3), understand ways to be involved in the campus community university (2.7/3), and enhance their education outside of structured classes (2.6/3). Twenty-eight (28) of 31 Group A respondents recommended continuation of the biweekly listserv (two respondents indicated maybe to continue them) and we expect to continue the listserv emails for the foreseeable future. Consistent with the research of others (Atkins, et al., 2020; Kim, 2009), the opportunity emails provide a secondary source of mentoring, albeit passive, that aids students in finding resources and opportunities. Though the emails were not meant to foster connections between STEM students, there would seem to be a small positive effect on STEM cohort connections (2.2/3).

Table 2. Mean Group A student responses (fall 2022, fall 2023, and fall 2024) for Likert statements related to the biweekly opportunity emails. Three-point Likert scale (Agree = 3, Neither Agree nor Disagree = 2, and Disagree = 1).

Likert Statement	Mean Response (*n* = 30)
The biweekly emails helped to connect with other First2 participants at WVU.	2.2
The biweekly emails helped to connect me to the First2 Institutional Team (faculty, staff, and student directors/co-chairs).	2.4
The biweekly emails helped me identify resources necessary for my success in college.	2.7
The biweekly emails encouraged me to engage in career planning.	2.6
The biweekly emails helped me to understand ways to be more involved with the campus community.	2.7
The biweekly emails assisted me in finding opportunities to enhance my education outside of structured classes.	2.6
The biweekly emails made me more positive toward majoring in STEM.	2.6

Belonging

Mean responses to the ten (10) belongingness Likert statements along with their sub-scale means and overall *Belonging in STEM* are provided in Table 3. Overall, mean scores for all ten Likert statements are high and range from a low of 4.2 to a high of 4.6 out of five indicating that respondents feel that they belong in STEM. The subscale for perceived *Belonging in the STEM Communit*y (based on statements 1-5) averages to 4.5 (out of 5). The subscale for *Belonging in Science/Mathematics Classes* (statements 6-10) averages 4.4 (out of 5). Whereas overall *Belonging in STEM* averages to 4.4 (out of 5).

As the belonging data was of the post-experience type and we did not collect corresponding pre-experience data, we were unable to determine if respondent's level of STEM belonging was affected by

receipt of the biweekly, opportunity emails. However, respondents also ranked a follow-up Likert statement of "*My experience with the biweekly emails this semester has positively influenced my sense of acceptance and belonging at college*." The mean response of the 30 respondents to this statement was 4.2 (of 5). This ranking along with respondents' overwhelming recommendation for continuation of the biweekly opportunity emails in addition to their text responses to open-ended questions indicates to us that we have assisted students in perceiving a greater sense of belonging in STEM. As outlined by Tinto's model for successful institutional intervention in higher education, the opportunity emails are promoting more inclusive practices including setting expectations, providing support and frequent assessment and feedback, and promoting involvement. (Tinto, 2012)

Table 3. Mean Group A student responses (fall 2022, fall 2023, and fall 2024) for Likert statements related to *Belonging in the STEM Community* (1-5) and *Belonging in Science/Mathematics Classes* (6-10). Five-point Likert Scale (Strongly Agree = 5, Somewhat Agree = 4, Neither Agree nor Disagree = 3, Somewhat Disagree = 2, and Disagree = 1).

Likert Statement	Mean Response (n = 30)
1: I feel accepted in my campus's STEM community.	4.6
2: I feel I fit in with my campus's STEM community.	4.6
3: I feel comfortable in my campus's STEM community.	4.5
4: I feel respected in my campus's STEM community.	4.4
5: I feel a sense of belonging in my campus's STEM community.	4.3
Sub-total average (Belonging in STEM Community)	**4.5**
6: I feel I fit in when I am in science and mathematics classes.	4.3
7: I feel respected when I am in science and mathematics classes.	4.5 (n = 29)
8: I feel a sense of belonging when I am in science or mathematics classes.	4.3
9: I feel accepted when I am in science or mathematics classes.	4.4 (n = 29)
10: I feel comfortable in science or mathematics classes.	4.2
Sub-total average (Belonging in Science/Mathematics Classes)	**4.4** (n = 29)
Overall Average (Belonging in STEM)	**4.4** (n = 29)

Representative comments from Group A students pertaining to the biweekly listserv emails are provided below. The first set of comments support the assertion that opportunity emails should be continued because (i) they are valued by student recipients and (ii) bring enhancing opportunities to their attention.

I think that these emails are valuable. Even if I didn't always read over them in depth, it is helpful to have consistent emails they keep me focused on the future and prioritize experiences outside of academics.

I go through them each time and have actually found multiple programs through these emails!

The opportunities in these emails are great for any STEM student looking to get the most out of their degree.

I probably would not be aware of the opportunities mentioned in the emails if they weren't sent out.

The biweekly emails are like a program search summarized, cutting down the inordinate amount of time I'd spend searching for them myself as well as bringing tons of novel programs and opportunities to my attention. They've been extremely helpful to me!

I think they are extremely helpful for our students. I wish I would have had something like this in the first two years of college.

Indirectly, one student indicated that the opportunity emails assisted them in feeling that they belong.

It diffenitely [sic] kept me updated on things I wasn't aware and it made me feel like I am apart [sic] of something.

Change to Professional Email Platform

Near the end of the fall 2024 semester, we changed email delivery platforms from basic to third-party professional. We asked fall 2024 survey respondents (in Group A), who had experienced both delivery systems (6 responses), to provide input. Sample student comments are provided below.

The information is organized and easy to understand and find.

I like the organization and appearance of these emails. It makes it easier to skim for information I consider important. It also helps the First2 Network appear more professional as an organization.

They are organized and easy to skim through them.

Anecdotally, this change indicates that professional aesthetics are conducive to interaction, and thus, increased belongingness.

At the same time, we expanded the recipient email list to include all undergraduate STEM majors from

underrepresented demographics. Our list of recipients expanded from about 100 to over 3000. Thus far, seven opportunity emails were sent to the Group B expanded list with 25,654 total sends, an opening rate of 76.0%, a click rate of 1.7% (ranging from 0.6% to 2.5%), total clicks of 936 (ranging from 33 to 191), and an unsubscribe rate of 0.04%.

Future Directions

We will continue the biweekly opportunity email project and its assessment for the foreseeable future. To appropriately address whether the opportunity emails affect students' feelings of belonging in STEM, we will use retrospective pre/post surveys (Howard et al., 1979; Sibthorp et al., 2007). The retrospective approach eliminates the need for matching survey responses, pre- to post-, and collecting identifying information from respondents. Finally, retrospective pre/post surveys help eliminate response shift bias by accounting for changes in respondents' understanding of survey items resulting from their exposure to the project.

Conclusions

In all, our project of informing underrepresented STEM students of enhancing opportunities to increase belongingness and, thus, collegiate persistence is consistent with prior studies which show that early and consistent connection with students is a positive prognostic factor for success in college (Hausmann et al. 2007). Though first-generation and other underrepresented students face countless barriers upon entering college, the correct support and sustained relationship with the greater community is invariably helpful in amplifying the confidence needed to earn a college degree (Atkins et al., 2020; Ahmed et al., 2021). Indeed, throughlines between college faculty, career opportunities, and students (such as the biweekly opportunity emails) connect and engage students in a way that leads to success. These efforts continue to make a difference in creating a more equitable culture in higher education.

The results of the biweekly opportunity email project highlight how small incremental, low-stakes institutional changes can be straightforward and cost-effective (free/nominal cost for email delivery platform) yet have the potential to improve students' connection and belonging to STEM. In addition, the quasi-experimental PDSA framework for documenting quality improvement allows for replication and scaling of small changes. This is important for faculty with high teaching and service commitments. The PDSA framework provides a method to track, formatively assess, and document change work.

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