An investigation into gender diverse populations in hackathon environments

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This paper presents an investigation into whether there are any barriers to the participation of gender diverse student populations in engineering hackathons. There has been some research into the experience of women in hackathons, which has shown that hackathons can be alienating, or even hostile, towards under-represented groups in engineering.

This paper is part of a larger research study to identify whether (or not) STEM environments are providing safe and inclusive spaces for people of all genders to encourage diversity and equity within this field. Pertinent to this paper, data collection was a pre-survey and post- survey over the course of two hackathons, one offered through a women-centered space and the other to the general student population. The Situational Motivation Scale (SIMS) survey instrument was given to participants of the 2 events; once at the start of each event, and once again near the end. The study participants were asked to generate a unique ID code so that their responses could be connected across the survey offerings.

In total, approximately 70 students filled in the first survey, and 10 filled in the second across both hackathons. The results suggest that women participating in hackathons with the general student population may exhibit less intrinsic motivation than their male peers, but that events which are designed to be welcoming to gender-diverse participants can increase their intrinsic motivation.

1 Introduction

Co-curricular STEM-focussed events like hackathons are growing in popularity at university campuses worldwide, however, there have been few examinations of differences in participation rates at these events based on student identity. This paper investigates motivational differences in different student populations when participating in hackathon-type events to better understand how these events are serving the diverse student populations in engineering programs. It is well understood that motivation influences the intensity, quality, and persistence of learning in students [1]. Self-determination theory is one approach to understanding human motivation which relies on the concepts of autonomy, competence and relatedness to understand motivation [2]. Through the lens of self-determination theory, researchers have identified three general categories of motivation: intrinsic motivation, which is internally driven; extrinsic motivation, which is more externally driven; and amotivation or the absence of motivation. A person with more intrinsic motivation than extrinsic motivation (or amotivation) can be expected to show more interest, confidence, and excitement; and are expected to exhibit enhanced performance, persistence, and creativity [2]. Generally, then, pedagogies that create situations where students are intrinsically motivated to participate will have better learning outcomes for participants than pedagogies which rely on external motivators like rewards and punishments.

Vallerand [3] describes a hierarchical model of motivation where factors at three levels (global, contextual, and situational) impact one's motivations, and thus the affective, cognitive, and behavioural outcomes of a situation. They suggest that the global level impacts the contextual level, and the contextual level impacts the situational level, and that within each level, feelings of autonomy, competence, and relatedness will impact one's intrinsic motivation, extrinsic motivation, and amotivation. For teachers, it is generally the situational level where there is the most control, and so it will be the focus of this paper.

One instrument for assessing the situational motivation of participants in an activity is the Situational Motivation Scale (SIMS) developed by Guay *et al.* [4]. In it, they sought to measure four types of motivation which operate at the situational level. The four types, from highest impact on self-determination to lowest, are:

1. Intrinsic motivation – behaviours engaged in for their own sake, for the pleasure and satisfaction from performing those behaviours,
2. Identified regulation – a type of extrinsic motivation for a behaviour chosen by oneself but which is a means to an end,
3. External regulation – a type of extrinsic motivation regulated by rewards or avoiding negative consequences, and
4. Amotivation – behaviours which are engaged in without a sense of purpose and no expectation of reward.

1.1 Hackathons

Traditionally, a hackathon has been described as a fast-paced computer programming event [5] where participants collaborate to create software-based projects in a time frame ranging from a single day to a week [6]. More recently, hackathons have shifted to cover a wide range of issues and many now focus on causes related to social good [7]. Hackathons have become increasingly popular amongst post-secondary institutions, as they provide authentic, hands-on learning opportunities for students to gain experience with tools and programs used by working professionals [6]. In addition to hands-on learning, hackathons provide students with opportunity to network and work on projects that can impact social change [5].

Prior studies have shown that participating in extra-curriculars can increase student interest in STEM careers and improve technical self-efficacy, particularly in women [8]. Despite this, representation of women in hackathons is still very low [5], resulting in this group missing out on professional development and employment opportunities [6]. Previous studies have found that hackathon environments can be unwelcoming and even hostile towards women [6] [7]. A survey of women students who did not enjoy their past hackathon experience found that physical discomfort, lack of technical skills (and limited opportunity to learn these skills during the event), and the intense hacker culture were top reasons for not enjoying their experience [6].

Suggestions have been made on how to make hackathons more women-friendly, including hosting women-only hackathons, increasing the representation of women mentors, having codes of conduct around exclusionary behaviour [6], broadening recruitment to women-centered spaces on campus, and using gender-neutral language in advertising [7]. Adding a light structure to the event with mentor check-ins [6], using beginner-friendly language, and eliminating or significantly decreasing the size of prizes [6] [7] are strategies to help reduce the competitive feel and make hackathons a more welcoming environment for novices.

1.2 Event Structures

Data for this study was collected over the course of two hackathons, one offered through a women-centered space and the other to the general student population.

The Women in Engineering (WiE) hackathon was a small scale (<100 participants), single-day event meant to provide a safe space for first time hackers to learn about hackathons. The target audience was women-identifying students, however all genders were welcome to attend. Participants with no prior experience were encouraged to register and students were able to sign up with a team or as an individual, to eliminate the pressure of finding a team as a requirement for participation. The WiE hackathon was structured to minimize competition between participants and eliminate novice fears for those who have never participated in a hackathon. All participants were given the problem statement in advance, optional workshops on the basics of app/web development were offered, and many women-identifying mentors and industry representatives were available throughout the day to offer support and guidance. The problem statement for the WiE hackathon was centered around social good and participants were encouraged to present their ideas at the end, even if their project was not finished. The goal of the event was to improve participants' comfort in a hackathon environment, increase technical self-efficacy, and create a sense of community and belonging for women-identifying students.

The second hackathon, the Toyota Innovation Challenge (TIC), was a larger (~150 participants), 2.5-day event with a problem sourced from an automotive industry partner. As with the WiE hackathon, participants with no prior experience were encouraged to register, and students were able to sign up as individuals or in a team. There were competition elements to the TIC, including prizes awarded by engineers from Toyota Motor Manufacturing Canada (TMMC), however participant learning was emphasized throughout the event: in its structure, and through the supports provided (see [9] for more information on how this event was structured to emphasize student learning). The TIC also had an optional workshop, offered Friday evening before the event started, to introduce students to the technologies they would be leveraging in their solutions. The challenge was revealed to all the participants at the same time on Saturday morning and was a simplified and scaled-down version of a real problem TMMC were solving in their automotive assembly plants. In the offering of the TIC that was studied for this research, students could opt in to either a mechanical challenge, which focussed on designing and implementing a robotics system to automate a menial task in the assembly of a vehicle, or a software challenge, which focussed on the automated inspection of the task (in this case, the task was to apply a sticker over a hole). Approximately 75% of TIC participants opted for the software challenge and 25% for the mechanical challenge. For the organizers, the goal of the event was to provide an interesting challenge where students could learn about robotics and machine vision techniques and apply their skills to a real problem. For the industry partner (TMMC), who are a significant employer of co-op students from the host institution, the event was a way to show students the types of problems that are being solved every day in their sector, and to build their talent pipeline for both co-op employment and employment post-graduation.

2 Methods

Both events being investigated were designed to be welcoming to participants from all programs and all skill levels. Students were not selected to participate based on aptitude, but simply on a first come first serve basis. In their own way, each event was seeking to drive students' intrinsic motivation to participate and learn. This begs the question: to what degree were they successful in doing that?

This paper is part of a larger research study to identify whether (or not) STEM environments are providing safe and inclusive spaces for people of all genders to encourage diversity and equity within this field. The pertinent research questions for this paper are:

1. What motivates students to participate in hackathons?
2. How does their motivation change during the duration of the event?

Data collection consisted of two surveys delivered over the course of two different extra-curricular hackathons; one offered through a women-centered space (herein referred to as the Women in Engineering or WiE hackathon), and the other to the general student population (the Toyota Innovation Challenge or TIC). The study participants were asked to generate a unique ID code so that their responses could be connected across the survey offerings. Each survey consisted of the student-generated ID, a series of demographics questions adapted from the campus equity survey plus program and academic year, the Situational Motivation Scale (SIMS) survey instrument [4], and an open question asking students why they chose to participate in the event. The surveys were given to participants at the start of each event and again near the end. This study was approved by the institutional research ethics committee.

In total, 68 students filled in the first survey (53 from the TIC event, and 15 from the WiE event), and 10 filled in the second (6 from the TIC event, and 4 from the WiE event). The respondents to the TIC event survey included 17 who self-identified as women, 42 who self-identified as men, and 1 who self-identified as questioning their gender identity; respondents to the WiE event survey included 17 self-identified women and 1 self-identified man.

Data cleaning was done in Excel and statistical analyses were completed in Stata 15. Statistical methods included the Wilcoxon signed rank sum test, and the Kruskal Wallis test to investigate differences in the means of responses to the SIMS instrument across different populations; and a linear regression to investigate intersectional effects on stated respondent motivation. The qualitative analyses conducted were content analyses with inductive coding [10].

3 Results

3.1 Quantitative Results

The SIMS instrument asked students to respond to 16 prompts on a 7-point scale (where 1 corresponds to 'not at all' and 7 corresponds to 'exactly'). In this instrument, there are four prompts which relate to each of intrinsic motivation, identified regulation, external regulation, and amotivation. To verify the results of the SIMS instrument, Cronbach's alpha scores were calculated for each of the four prompts that correspond to the same type of motivation for both the first and second surveys. The alpha score was above 0.7 for all eight collections of prompts except for the external regulation scores from the first survey which had a value of 0.63.

Table 1 shows the combined means and standard deviations for participant responses to the four types of motivation at the start and end of the events. Intrinsic motivation, identified regulation, and external regulation all increase from the start of the events to the end, and amotivation decreases. The Wilcoxon signed rank sum test (non-parametric alternative to the paired t-test) was calculated, and none of the differences in means were statistically significant.

Table 1 Mean (std dev) of motivation at start of event and end of event; higher values represent stronger correspondence

	Intrinsic	Identified Regulation	External Regulation	Amotivation
Start of events	4.2 (1.16)	1.6 (1.32)	4.4 (1.07)	1.8 (1.59)
End of events	4.7 (.75)	2.2 (1.71)	5.5 (.59)	1.4 (1.14)

To investigate differences in the motivations of different student populations, the Kruskal Wallis test (a non-parametric alternative to an ANOVA) was used to compare the means of the four types of motivation on the first (i.e. pre-event) survey. The results when comparing the means between the two events for all four types of motivation were not statistically significant. **Error! Reference source not found.**Figure 1 shows box plots for the four types of motivation by event for all participants. Limiting the plot to just women-identifying participants at the two events results in the box plot shown in Figure 2.

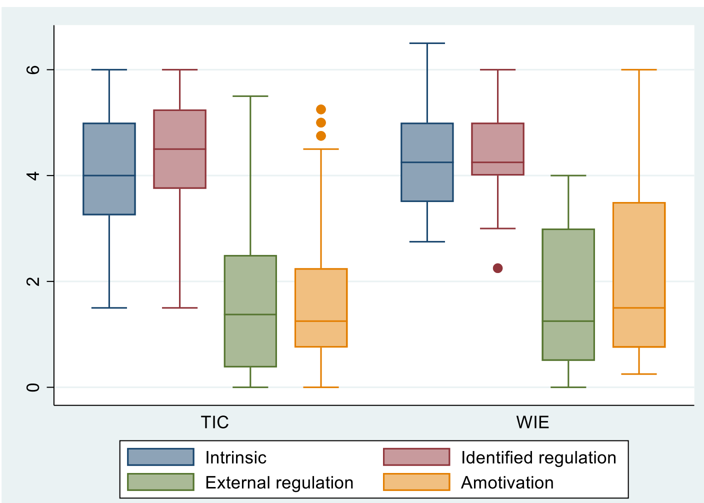

Figure 1 Box plots of 4 types of motivation between the two events, pre-event survey

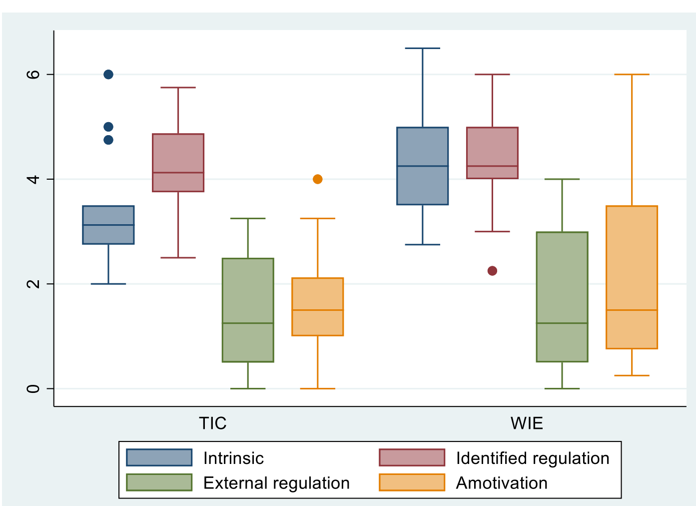

Figure 2 Box plots of 4 types of motivation between the two events, women-identifying participants only, pre-event survey

Table 2 shows the mean and standard deviation for each of the four types of motivation by gender and by event. 15 women-identifying participants filled in the SIMS portion of the survey in each event (for a total of 30 across both events). No man-identifying participants filled in this portion of the survey at the WiE event while 34 man-identifying participants completed the survey at the TIC event.

Table 2 Mean (std dev) of 4 types of motivation, start of event survey

Event	Intrinsic		Identified regulation		External regulation		Amotivation	
	Male	Female	Male	Female	Male	Female	Male	Female
TIC	4.43 (0.18)	3.3* (0.27)	4.6 (0.21)	4.3 (0.22)	1.6 (0.23)	1.4 (0.28)	1.6 (0.26)	1.7 (0.27)
WiE	-	4.4* (0.29)	-	4.4 (0.25)	-	1.8 (0.38)	-	2.4 (0.54)
Combined	4.43** (0.18)	3.8** (0.22)	4.6 (0.21)	4.3 (0.16)	1.6 (0.23)	1.6 (0.23)	1.6 (0.26)	2.0 (0.30)
*p<0.01, **p=0.06								

The Kruskal Wallis test was re-run to test the difference in means between the two events for woman-identifying participants only. This resulted in a statistically significant difference in the means for intrinsic motivation between the two events ($p<0.01$) with woman-identifying participants at the WiE hackathon reporting higher levels of intrinsic motivation (mean=4.4) than at the TIC (mean=3.3). There were no statistically significant differences in the other motivation types. Looking at the combined results from both events, the difference in means for all four types of motivation by participant gender were not statistically significant, though intrinsic motivation bordered on statistical significance ($p=0.06$) with man-identifying participants reporting stronger intrinsic motivation (mean=4.43) than woman-identifying participants (mean=3.85) or other genders (mean=3.75). **Error! Reference source not found.** shows box plots for motivation by participant gender.

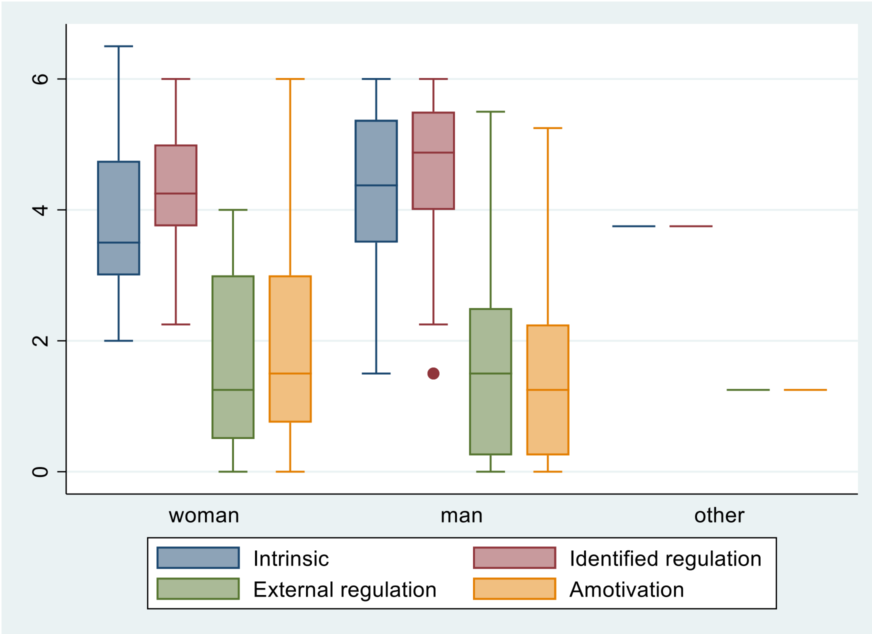

Figure 3 Box plots of 4 types of motivation by participant gender

To investigate the interactions of event type, gender, program of study, and race on intrinsic motivation, a linear regression was calculated. This model assumed the base participant was a white woman in the TIC hackathon in the department of Civil and Environmental Engineering. The resulting model had an R^2 of 0.35, and there were two statistically significant relationships: woman-identifying participants were predicted to have more intrinsic motivation in the WiE hackathon (coefficient=1.24, p=0.014); and man-identifying participants were predicted to have more intrinsic motivation than women (coefficient=1.04, p=0.010).

3.2 Qualitative Results

At the end of the survey, participants were provided an open text box to explain why they chose to participate in the event. In total, 47 responses were collected (38 from the TIC hackathon, and 9 from the WiE hackathon). An inductive content analysis with open coding [10] was performed to summarize these qualitative data for publication. Most responses included a single dominant reason for why they chose to participate, though several included two. For responses with more than one reason given, they were counted for each mentioned sub-theme.

Across all 47 responses, learning was the most common reason given for participating in the event, followed by career development, social reasons, fun, personal interest, and free food. Table 3 summarizes the themes and subthemes across all responses from both hackathons.

Table 3 Summary of themes: "Why did you choose to participate in this event?", n=47

Theme	Subtheme	Sample quote
Learn (n=26, 55%)	Technical topics (n=11): machine learning, computer vision, programming	“To learn more about software and reinforcement learning”

	No topic (n=10)	"To learn more and be surrounded with others in my field"
	Mechanical design (n=2)	"I can get more experience with working in a group & doing mechanical projects"
	Teamwork (n=2)	"I can get more experience with working in a group & doing mechanical projects"
	Problem solving (n=1)	"To… be able to use my engineering knowledge to solve problems."
Career (n=12, 25%)	Resume building (n=10)	"To help my resume and gain mechanical skills"
	Explore career interests (n=2)	"Want to explore career interests"
	Networking (n=1)	"to potentially gain connections to Toyota"
Social (n=8, 17%)		"I thought it would be a good experience to learn and connect with others"
Fun (n=7, 15%)		"I think this event will be a good opportunity to … work on a fun project in my field."
Personal interest (n=7, 15%)		"Seems interesting and a good place to make connections"
Free food (n=2, 4%)		"Honestly? Because of the free food"
No answer (n=11, 23%)		

Table 4 shows the summary of themes and relevant sub-themes for the women-identifying respondents at the TIC hackathon. In general, the frequencies of the themes are similar to those in Table 3, though responses in the social, fun, and personal interest themes are lower (or non-existent).

Table 4 Summary of themes: "Why did you choose to participate in this event?", women at TIC hackathon, n=15

Theme (n=15)	Subtheme
Learn (n=7, 47%)	Technical topics (n=3)
	No topic (n=2)
	Mechanical design (n=2)
	Teamwork (n=1)
Career (n=4, 27%)	Resume building (n=4)
Personal interest (n=1, 7%)	
Social (n=1, 7%)	
No answer (n=2, 14%)	

Table 4 shows the summary of themes and relevant subthemes for the nine responses recorded at the WiE hackathon. Compared to the responses for both events, a similar percentage of attendees at the WiE hackathon reported "learning", "personal interest", "fun", and "free food" as the reason they attended. There were differences in the percentage of attendees who listed social reasons and career reasons for the WiE hackathon, however. There was a much larger percentage of attendees who listed social reasons for attending the WiE hackathon compared to the entire population, and a smaller percentage who listed career reasons for attending.

Table 4 Summary of themes: "Why did you choose to participate in this event?", WiE hackathon only, n=9

Theme	Subtheme
Learn (n=5, 56%)	No topic (n=5)
Social (n=5, 56%)	

Personal interest (n=2, 22%)	
Career (n=1, 11%)	Resume building (n=1)
Fun (n=1, 11%)	
Free food (n=1, 11%)	

4 Discussion

The key finding of this research suggests that women participating in large events with the general student body may have less intrinsic motivation than their male peers, and that focussing on creating an inclusive STEM environment prior to the event encourages gender diverse populations to choose to participate. The development of intrinsic motivation can be related to building confidence in one's own skills that can then be transferrable to motivation to pursue technical careers. Looking at the differences and similarities of the WiE and TIC hackathons, the elements of the inclusive STEM environment that may lead to more intrinsic motivation for gender diverse populations are the focus of creating a women-centered space for beginner hackers, and overarching themes that encourage societal impact. The interaction of participants is also an unexplored area in this study, and both the encouraging and discouraging effects of any interactions between participants based on gender identity, as described by Nguyen *et al.* [11], could be an important effect on motivation. The WiE hackathon theme was socially oriented when compared to the TIC hackathon, introducing the theme of "tech for good" versus the development of automated processes for manufacturing, respectively.

The data did not show a statistically significant change in motivation levels across the duration of the events, though the means presented in Table 1 clearly change from the pre-survey to the post-event survey. The lack of statistical significance could be due to the small population of students who filled in both surveys; in total, only 10 students filled in the second survey across both events. The small population in the post-event survey are a significant limitation of this study and limit the conclusions that can be drawn from the data.

The qualitative responses in the surveys show a diverse range of motivations to participate in a hackathon, and that differences in event structure will motivate students differently. For organizers of these types of events, this would suggest a diversity of hackathon themes and structures may be useful in motivating the diverse student body in engineering programs. The qualitative responses demonstrate that in the WiE hackathon there was a larger drive to participate due to the social interactions within the event when compared to the TIC hackathon which emphasizes the importance of learning. This contributes to existing knowledge that using beginner-friendly language in advertising [7] and hosting a women-only hackathon [6] promotes greater representation of women, and motivation for participation. Additionally, the solutions presented in the WiE hackathon required an understanding of social interactions amongst people in addition to technical skill development, whereas the TIC hackathon focussed on technology within manufacturing environments. The inherent structure of the two events, and their different goals for the respective organizers, may further influence the hackers' motivations to participate in either event.

For future research, a possible direction is to leverage this knowledge to see how women who started with the WiE hackathon would then be motivated to participate in an all-gendered event, such as the TIC hackathon. The goal would be to identify if creating a baseline of experience and hacker skills would then intrinsically motivate women to continue to expand on their skills, rather than being motivated through social interactions. Additionally, investigating the effect of the hackathon theme as a driver of motivation by leading an all-gender hackathon with a similar focus on societal impact as the WiE hackathon would be insightful. In this environment, it may be possible to assess the diversity of participants, as well as the motivation for participation to study the impact of the event's theme on participant motivation.

One significant limitation of this study is the relatively small population of women-identifying students who responded to the surveys, making meaningful statistical comparisons challenging. Alternative means of collecting qualitative results, such as conversations with participants during the hackathon and/or focus groups following the event could yield more rich qualitative data than the final surveys used here. To address gaps in the results, it is recommended that future research involves a greater emphasis on focus groups with qualitative data collected over the course of the event in both a women-centred environment and an all-gender hacking environment.

5 Conclusion

This paper presented an investigation into differences in motivation for gender-diverse populations in engineering to participate in extra-curricular hackathons. Surveys were given to participants at two events: a women-centered event, and an event for the general student population. The results showed that participants in these events demonstrated a measurable, but not statistically significant increase in motivation levels – and a drop in amotivation – from the start of the event to the end. The results also showed that men reported higher levels of intrinsic motivation than women at the general population event, but women at the women-centered event showed similar levels of motivation to their male peers. A thematic analysis of student responses to the question of why they chose to participate in the event showed most students were there to learn, but that women participants in the women-centered hackathon were more motivated to participate for social reasons than in the hackathon with the general student population where career development was the number two reason given. These results suggest event organizers need to carefully consider the theme and structure of hackathons, as well as their advertising materials to support the intrinsic motivation of gender-diverse populations.

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