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Cover Page Footnote

The leadership team of NWI-MTC is thankful to Dordt University for its ongoing support in hosting the NWI-MTC on campus. We would like to thank the American Institute of Mathematics for the support that made this research possible as well as its role in curating online resources which sustain circles. Funding for this research was provided by an NSF NOYCE grant under award number DUE-1660632.

Stipends Successfully Swell Circle

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The efficacy of stipends in drawing new teachers to participate in a Math Teachers' Circle and encouraging previous participants to attend meetings regularly was investigated in this study. A kickoff event was planned to start the year with more fanfare than usual. Stipends were advertised for teachers who attended at least three meetings. Matched pairs data analysis and survey results were used to investigate the observed increase in attendance.

Keywords: Math Teachers' Circle, Stipends, Attendance

1 Circle Background

The Northwest Iowa Math Teachers' Circle (NWI-MTC), [7], is hosted at Dordt University and draws local teachers from various schools in a rural area. Most participants are high school teachers, though a few middle and elementary teachers also attend regularly. Many of the teachers in this circle teach in schools with only one or two math teachers. As such, the circle is a place where math teachers find community, share ideas, and develop meaningful professional relationships, in addition to the benefits related to the enjoyment of mathematics that is common among all circles. By increasing attendance at circle meetings, we hope to share those benefits with more teachers and schools in the area and increase camaraderie in our circle. The steps our circle took in 2019-2020 to achieve that goal and their effects are the focus of this research.

A novel aspect of the NWI-MTC is that undergraduate students from Dordt University are invited to attend the circle. The students who attend benefit from their interactions with veteran teachers. Additionally, these students often complete their student teaching with a teacher they met while

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attending the circle. Many students have reported that these interactions are meaningful in their development as pre-service teachers as they add practicality to the theory they are learning in their pedagogy courses. For example, one participant said, "*It is fun learning with people who enjoy the subject matter as much as you.*" An in-service teacher reported, "*I enjoy picking up different bits and pieces and using it with my students.*" Dordt University Noyce scholars (majoring in Math Education) are regular attendees of these meetings. This is unsurprising as the goals of both programs align. Having increased and more diversified attendance by teachers at these meetings will broaden the impact of the circle and add to its collaboration.

The NWI-MTC is a small circle that began in 2014 with typical meetings of 6-10 university faculty and teacher participants and grew to 8-14 in recent years by drawing more teachers and including undergraduate math education students as well. Despite some growth, the leadership team believed that more was possible; perhaps 15-25 regular attendees could reasonably be achieved based on the number of teachers in the rural area and classroom capacity in the meeting space. Many teachers knew of other area teachers that were somewhat interested, but rarely or never attended. The desired growth was to come in two ways: by attracting new teachers who had previously not attended a NWI-MTC meeting before and by increasing the number of meetings attended by teachers who only participated occasionally. The practical effect of such growth could mean that most area schools would have one or more math teachers regularly finding a community of practice. These teachers could learn from each other, develop in their teaching pedagogy and mathematical knowledge and dispositions, discuss common challenges, and support each other. The study herein reports on the effects of that plan which was made possible by utilizing a grant from the American Institute of Mathematics.

2 Study Design

Teachers who attend NWI-MTC regularly report informally that they find value in attending meetings, but also that the busy schedule of a teacher limits the number of meetings they are able to attend. Two primary goals that the NWI-MTC has for its attendees are to experience the joy of doing mathematics and to network with area mathematics teachers. However valuable these experiences are, a stipend could add to the perceived value, or offset travel expenses for teachers who need encouragement to attend more regularly. Perhaps teachers who had never attended before might, because of a stipend, choose to participate for the first time. Many math circles offer a stipend to participants, e.g., [9]. A faculty teaching circle at the University of

Nebraska-Omaha saw strong participation among professors, though the authors indicated that participation continued after the $300 stipends were later cut, see [8]. Although related, that does not answer the question of whether adding a stipend to an already existing circle could increase attendance. Does the presence of a Math Teachers' Circle in a location naturally draw all the interested teachers, or could even more be drawn with a stipend? Does the small stipend offset the distance traveled for participants who live up to 30 miles away?

Not all successful Math Teachers' Circles have stipends for participants, see e.g., the Northern Colorado Math Teachers' Circle which had stipends for the leadership team but not participants, see [5]. The NWI-MTC is itself an example of a successful circle running without stipends. This makes it a good candidate for a such a study, because this circle is at a point in its life where the "new car smell" is off and attendance is likely to decrease not increase. So, the injection of stipends correlating with an increase in attendance is a strong indicator of the efficacy of that incentive on teacher participation. The results of such a study are of value to other circles that may be wondering whether investing limited financial resources into a stipend would be efficacious in growing attendance.

The decision was made to offer $100 stipends to teachers who attended at least three meetings. Typically, the NWI-MTC meets 6-7 times during the academic year, so this would still provide enough flexibility to make it attainable even for teachers with other commitments throughout the year. It seemed plausible that this may both bring in new teachers and make sparse attendees more regular. It is unclear from psychological research on motivation whether the stipend would have a net positive or negative impact on attendance. For example, from self-determination theory [3] it may follow that an extrinsic motivator, like a stipend, could disincentivize already motivated participants, but incentivize non-motivated potential participants. However, given how many leverages there are on teachers' time, it seems entirely reasonable that multiple motivating factors may need to work in concert to cross the threshold required to deliver a teacher on a Saturday morning to a math circle meeting. Adding a stipend to the list may be a tipping point for some, and thus, is worthy of an investigation. As the circle is well-established, the study design largely isolates that factor among the many other motivations in play.

While the study is primarily considering whether stipends could have an effect on rates of attendance, it is worth noting that stipends may also help participants feel valued. This may have motivated some to come, not for financial gain, but for the sense of respect that university faculty had given them by writing a grant to compensate their time for attendance. This is

a consideration given that only teachers were eligible to receive the stipend, not university faculty or students. Having more participants means a bigger community, more ideas to be shared, and a larger potential impact on classrooms in the area. These are all goals that are valuable to the math education community. Whether expanding this reach could be done through motivation via stipends is a question that needs to be answered, not only for NWI-MTC but for other circles with similar goals and values. It also must be answered because research, e.g., [1], suggests that payment in some cases disincentivizes participation. This study therefore adds to the literature on motivation in Math Teachers' Circles.

It is not entirely possible to disentangle all other variables. Not all relevant variables could be controlled. For example, the mathematical topics, see [7], have always varied from session to session, but the nature of the topics in 2019-2020 were similar to those in previous years. Meeting time and length were kept the same and the typical presenters and types of topics remained consistent. Nevertheless, one difference was that the first meeting of the year featured a "kick off" vibe with a meal following the meeting. (Light refreshments of coffee, juice, and pastries were typical in the past.) We also flew in an outside speaker from another successful circle who lead the kickoff meeting with a low-floor, high-ceiling topic that was very accessible to teachers at any level, but still deeply interesting. After the first meeting, the remaining meetings were structured the same. It is possible that as attendance increased, the meetings themselves improved in perceived quality via a sense of identity or community. The NWI-MTC has always had a goal of providing a welcoming community of mathematical practice to all participants, but as new people came and found a home, it may be hard to disambiguate from the attendance data alone whether the increased attendance was due to the stipend, random chance, or some other factor. Certainly to grow, some teachers would have to come for the first time; thus the kick-off meeting aimed to achieve that outcome. Attendance data was gathered using sign in sheets for each meeting from 2017-2020.

One caveat that needs to be mentioned is that COVID-19 interrupted the 2019-2020 academic year, causing the cancellation of the last two meetings of the year (March and April). So, the available data is based on meetings in September, October, November, and February both for the 2018-2019 academic year, the control year, where no stipend was given, and the 2019-2020 year, where the stipend was given. It should be noted that in 2018-2019 there were two more meetings, but that data was not used for comparison. It is possible that, had attendance trends in 2019-2020 continued, the evidence for the effect of the stipend would have been stronger due to the increased power

from the larger sample size. However, due to the speculative nature of that line of reasoning, we will focus on the directly comparable data available.

We will also note that attendees at NWI-MTC meetings come from three groups: faculty at Dordt University, area mathematics teachers, and pre-service teachers from Dordt University. The attendance described below is only that of area math teachers, which is the primary group of interest for this study. For reference, typically about 2-5 university students and 3-4 university faculty attend the meetings as well.

3 Statistical Investigation

A matched-pairs analysis was performed using sign-in data from meetings in 2019-2020 compared to 2018-2019. For each teacher attendee, the number of meetings attended in 2018-2019 and in the treatment year 2019-2020 was compared. For the 2018-2019 year, only attendance from the September, October, November, and February meetings were utilized.

As seen from the summary statistics in Table 1, the average meeting attendance had been in decline, but rebounded above even the attendance from 2017-2018. Given that the primary change was the introduction of the stipends, it appears that they likely contributed to an increase in attendance at NWI-MTC among teachers.

Table 1

Average number of teacher attendees per meeting from 2017-2018 to 2019-2020.

Year	2017-2018	2018-2019	2019-2020
Average Attendance (All sessions)	6.50	5.86	8.50
Average Attendance (Sep. - Feb.)	7.00	5.75	8.50

Additionally, since granular data for each participant was available, a matched pairs analysis examined whether the stipends actually brought in new teachers or helped to increase the attendance for teachers who attended sporadically. Each column in Table 2 represents a unique teacher with meetings attended in both the 2018-2019 and 2019-2020 academic years (between September and February).

Note some of the important features made visible from the paired data in Table 2. Since the stipend required attending at least three meetings, we define a *regular* attendee to be one who attends at least three times. For clarity we have bolded these teachers in Table 2. Strikingly, the number of regular attendees doubled from four to eight in the treatment year - a key development

Table 2

Matched pairs data for each teacher attendee from 2018-2019 and 2019-2020 as well as the signed difference.

Teacher	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18-19	**4**	**4**	**3**	**3**	2	1	1	1	1	1	1	1	1	0	0	0	0	0	0
19-20	**3**	0	**4**	2	**4**	**4**	**3**	**3**	1	0	0	0	0	**4**	**3**	1	1	1	1
Diff.	-1	-4	1	-1	2	3	2	2	0	-1	-1	-1	-1	4	3	1	1	1	1

in line with the goals of the project. Further consideration shows that while there were five teachers who attended in 2018-2019 that did not in 2019-2020, including one regular participant, there were six completely new teachers in 2019-2020, two of which became regular attendees. More importantly, some of the attendees in 2018-2019 became regular attendees in the treatment year. Since teachers had to attend at least three meetings to receive the stipend, it is plausible if not likely that the stipend had a motivating effect on those teachers. The average of the differences is 0.58; that is, on average teachers attended about a half a meeting more than in the previous year. The key result made visible here is how the stipend likely encouraged teachers to attend regularly instead of sporadically.

This data (Figure 1) clearly demonstrates that an increase in attendance was observed as well as an increase in the number of regular attendees. We now investigate this data from a statistical perspective to see whether an increase of this magnitude could be possible by "random chance." With matched pairs data a t-test on the differences was conducted to examine whether the observed differences were statistically significant.

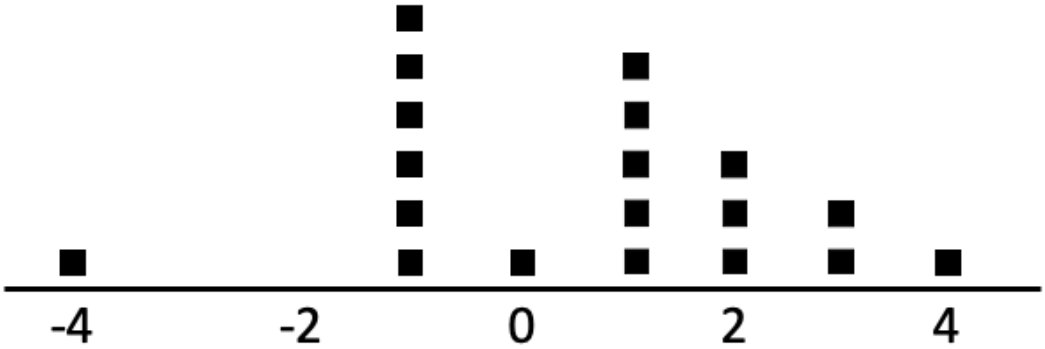

Figure 1. Line plot of observed differences.

The differences are on average more positive than negative, but because of the small sample size, there was inadequate power to detect a statistically

significant difference ($t = 1.31$, $p = 0.206$). The 95% confidence interval for the true mean difference is $(-.3483, 1.5063)$. The increase in attendance observed was simply not large enough, or the sample size too small, to give statistically significant evidence that the observed increase in attendance was caused by the stipends.

Regardless, the benefit for the teachers who found the circle for the first time and experienced the joy of mathematics from a perspective of inquiry cannot be ignored. This is especially true in a rural area where many mathematics teachers may not have a community of practice in their small schools. Isolation is a real experience for many educators in small, rural schools. Math circles may counter it, providing them with connection as well as quality professional development, in contrast to the often lower quality professional development available to rural teachers; see [2]. Additionally, the message sent to teachers about the value of their time (or compensation to offset travel expenses) may be equally important to retaining backbone teachers in rural areas; see [4].

Survey Data

To complement the quantitative methods described above, a survey, administered by SurveyMonkey, was e-mailed to each of the teachers who attended in 2018-2019 and/or 2019-2020. The survey was completed in August of 2020 and asked a total of eight questions including interest in future MTC attendance. The two questions relevant to this study follow:

1. In 2019-2020, \$100 stipends were were given to teachers who attended NWI-MTC at least three times. Because of this stipend I
   (a) attended more than I would have otherwise.
   (b) attended the same as I would have otherwise.
   (c) attended less than I would have otherwise.
2. If \$100 stipends were again available in 2020-2021 for teachers who attended at least three times, this would make it
   (a) much more likely for me to attend NWI-MTC at least three times.
   (b) more likely for me to attend NWI-MTC at least three times.
   (c) as likely as not for me to attend NWI-MTC at least three times.
   (d) less likely for me to attend NWI-MTC at least three times.
   (e) much less likely for me to attend NWI-MTC at least three times.

Interestingly, of the twelve respondents, two (16.67%) reported that they attended more than otherwise would have (Figure 2). The stipends did have an effect on at least two teachers according to their own admission. The other ten (93.33%) responded that they attended the same as otherwise. This is encouraging in that many teachers clearly attend due to the inherent value they find in the circle. Additionally, no teachers selected "attended less that I would have otherwise," indicating that the stipend did not serve as a demotivator. This possibility is worth considering as payment for an activity can decrease the perceived value of the activity; see for example [1] and [6]. In view of this research, it cannot be taken for granted that adding a stipend would increase attendance. Interestingly, at least for these teachers the stipend had a net positive affect so this is likely a case where the cautions from economic behavior theory are outweighed by the teachers accurately perceiving the value of the professional development.

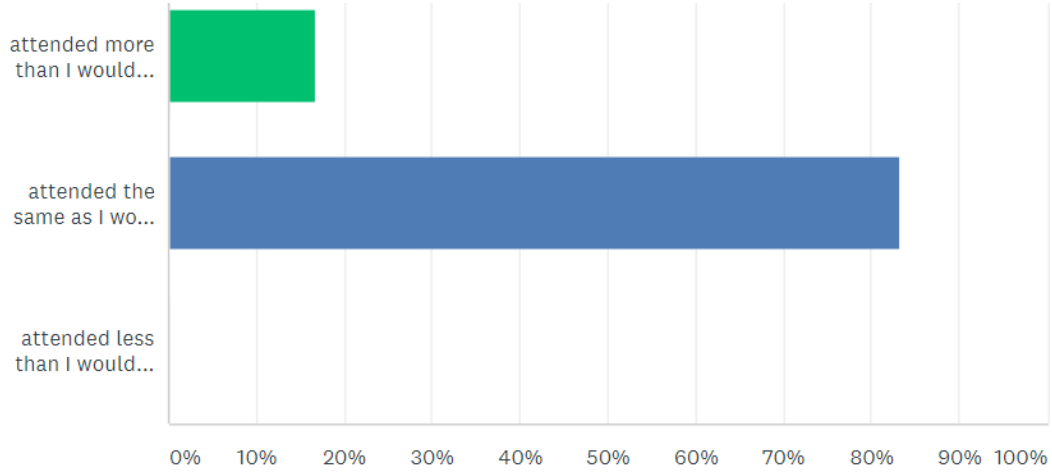

Figure 2. Survey data for question 1.

One might not necessarily expect the responses to the second question, shown in Figure 3, to be much different from the first, but when asked about future plans, we see a notable difference. Two (16.67%) indicate that attendance is much more likely, one who had answered (a) to question 1 and one who had answered (b), but six (50%) indicate that stipends would make it more likely. Only four (33.33%) now indicate their attendance to likely be unaffected. From these responses, it is clear that stipends certainly would not decrease attendance, but rather will result in maintaining or increasing attendance. There are some teachers in the sample for whom the stipend made the difference in their attendance.

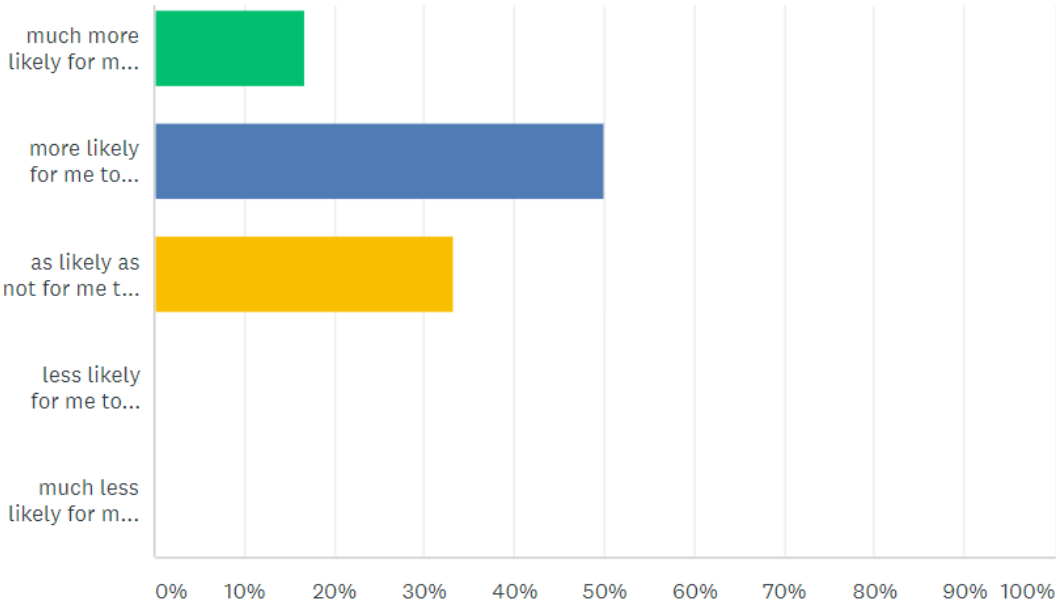

Figure 3. Survey data for question 2.

Conclusions

Descriptive data demonstrated that overall attendance increased during the treatment year and the number of regular attendees doubled. Moreover, the survey data supports the conclusion that stipends played a role, though not as strongly as expected. One limitation is that not all teachers completed the survey. The small sample size limited the power of statistical tests to detect differences. It should be stated that one cannot assume the teachers who participate in the NWI-MTC are representative of all teachers. The most fitting conclusion is that stipends are likely to increase attendance by pushing some teachers who are "on the fence" to try it out and push sparse attendees to become regular. One legitimate concern that arises from [3] is whether an external motivator like a stipend could negatively affect participation among internally motivated attendees. The survey data refutes this conclusion in both questions. This finding is important as it is a factor in other scenarios as shown in [1]. The data suggest that this could be a method for other circles which also aim to increase attendance overall or to develop regular attendees. The data did indicate an increase in participation among undergraduate students, so it is possible that increased participation among teachers has downstream effects on participation among pre-service teachers but that conclusion cannot be substantiated without further research.

Additionally, circles which are interested in administrating stipends may find that it is not onerous. Because our circle has a relationship with Dordt University that holds and processes the NWI-MTC grant funding, the stipends could be issued similar to an honorarium given to an outside speaker - a straightforward process for most universities. The director of the NWI-MTC collected W9 forms from participants when they attended their third meeting (the stipend threshold). At the end of the year, check request forms were then completed for all stipend receiving participants and the University mailed the checks.

Further study about the effect of stipends would be welcome in other Math Teachers' Circles. NWI-MTC plans to pilot a follow-up study offering stipends to undergraduate students investigating direct effects on pre-service teacher attendance and indirect effects on teacher attendance. Another angle of research would investigate the effect of stipends of various amounts as well as variation in the model in which the stipends are paid; for example, minimum threshold versus proportional to attendance. Finally, it may also be worth noting that if funding is exhausted, stipends may not be available in the future which could depress attendance; however, as noted in [8], this may not be a serious concern.

Acknowledgements

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