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WIP: Reliability and Correlation Findings from a Multi-Classroom Study of Evaluating Entrepreneurial Mindset Through Multiple Surveys

Emmanuel Tetteh Teye, Montana State University

Emmanuel Teye is a doctoral student of the Adult and Higher education program at Montana State University. He is interested in exploring the connection between entrepreneurship and engineering, STEM Education research, Students motivation, Belonging, Identity and Career choices in Higher education

Jeffrey Kinkaid, Montana State University - Bozeman

Jeff Kinkaid is an Assistant Professor in the Mechanical & Industrial Engineering Department of the Norm Asbjornson College of Engineering at Montana State University in Bozeman. Mr. Kinkaid serves in the Mechanical Engineering Technology academic program.

Prof. Stephanie G Wettstein, Montana State University - Bozeman

Stephanie Wettstein is a Professor in the Chemical and Biological Engineering department at Montana State University in Bozeman, MT. She has been the MSU KEEN lead since 2023 and is the Associate Director of the Montana Engineering Education Research Center.

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Abstract

Although surveys enable efficient and scalable data collection, self-reporting limits interpretive precision, particularly for abstract constructs such as entrepreneurial mindset (EM). This work-in-progress paper examines EM in engineering students using two previously developed surveys, the 34-item Engineering Student Entrepreneurial Mindset Assessment (ESEMA) and a 28-item EM assessment instrument. The study addresses whether these instruments demonstrate comparable reliability and sensitivity to short-term change within a single semester.

Across six engineering classrooms ($N = 205$), students completed one or both surveys at two time points during a semester. The 28-item survey demonstrated high internal reliability (Cronbach's $\alpha = 0.90$), while the 34-item survey demonstrated moderate reliability ($\alpha = 0.78$). Test–retest correlations were moderate for both instruments ($r = 0.56$–0.60), suggesting variability in student responses across time. No significant pre-post differences were observed across survey combinations, suggesting that EM, as measured by these instruments, is relatively unchanged throughout a single semester or that the changes cannot be measured using these instruments. However, statistically significant differences in EM scores were observed across engineering courses. The interdisciplinary, core course emphasizing sustainability had the lowest self-reported EM scores, whereas the Mechanical Engineering Technology course had the highest.

These findings contribute to ongoing discussions within the entrepreneurial engineering education community regarding instrument selection, construct stability, and the interpretive limits of self-reported EM measures. Future work will utilize the 28-item instrument and incorporate additional EM assessment approaches, such as concept mapping, to triangulate EM measurement beyond self-reported surveys.

Introduction and Background

The Kern Entrepreneurial Engineering Network (KEEN) emphasizes that engineering graduates should possess both technical skills and an entrepreneurial mindset (EM), in response to growing calls for an innovative, sustainable, and future-ready STEM workforce (Desing et al., 2022.; Yu et al., 2025). In line with this, entrepreneurial minded learning (EML) has been promoted by KEEN as a proven approach for nurturing EM in engineering and technical subjects (Comolli & Elmer, 2018; Wheadon & Duval-Couetil, 2016).

EM includes the attitudes, ways of thinking, and behaviors that shape how individuals identify problems, pursue innovation, and create value. The goal is that when engineers develop an EM, it amplifies their technical expertise by orienting it toward opportunity recognition, contextual awareness, and purposeful action that equips them to identify and frame complex problems, assess uncertainty, and deliver solutions that create value across diverse contexts (Jackson, Brunhaver et al. 2026). In doing so, this integration extends the role of engineering beyond technical optimization toward addressing pressing societal challenges and fostering conditions that support sustainable impact and human flourishing.

Key to building an EM, KEEN developed a pedagogical framework consisting of three core attributes: Curiosity, Connections, and Creating Value (3 Cs). Curiosity refers to an engineer's disposition to question assumptions, seek information about a rapidly changing world, and explore alternative or contrarian perspectives to accepted solutions. Connections emphasize the ability to integrate diverse sources of knowledge, perspectives, and experiences to generate deeper insight, while creating value focuses on situating engineering work within broader societal and human needs and translating ideas into solutions that deliver meaningful impact. The 3 Cs framework has garnered considerable attention and has been the foundation for numerous studies examining the entrepreneurial predispositions of engineering students (Bailey et.al, 2021; Desing et al., 2022).

Many engineering programs have integrated EM into both curriculum and extra-curricular activities through concrete implementation strategies, such as integrating entrepreneurial thinking into freshman courses, design projects, and curriculum modifications (Wang et al., 2017) while some have also started to utilize artificial intelligence for the cultivation, assessment, and application of EM both for students and faculty (Engineering Unleashed, n.d.).

According to Mallouk et al. (2019), teaching students EM through the 3 Cs helps them extend knowledge beyond classroom boundaries and recognize broader societal impacts. London et al. (2018), developed a comprehensive framework with twelve attitudes and seventeen behaviors mapping to the 3Cs. Gorlewicz et al. (2020) demonstrated EMLs practical application in curriculum design, while Riley et al. (2021) tracked how students' understanding of these concepts evolves. A recent study conceptualized entrepreneurial learning not as the transmission of discrete skills, but as a co-constructive process in which students actively develop interpersonal, cognitive, and entrepreneurial capacities through engagement with authentic problems (Ilyas et al., 2024). Extending this work, Sandhu et al. (2025) advanced an integrated curricular framework that embeds entrepreneurial thinking within core engineering learning activities that can be associated with enhanced ideation, risk assessment, user-centric reasoning, and innovation capabilities critical for engineering work in the 21st century. Although many assessments of EM exist (COMPASS, n.d.) and have been reported, there is no standard, accepted measurement.

Assessing the entrepreneurial mindset (EM) among engineering students and faculty is inherently complex and can be seen in the diverse range of available assessment tools (COMPASS, n.d.). Surveys, a common tool, offer broad reach, enabling longitudinal studies and efficient data collection within courses; however, their effectiveness is often constrained by the subjective nature of responses, the limitations imposed by the questions asked, and the potential for respondent fatigue. Multiple survey instruments have been developed to measure EM with commonly utilized ones being a 28-item survey developed by Li et al. (2016) and a 34-item survey developed by Brunhaver et al. (2018). The goal of this work was to compare and evaluate these two commonly used, validated surveys, developed by participants in KEEN, to measure entrepreneurial mindset (EM) through reliability and correlation analyses by addressing the following research questions: 1) do the 28-item and 34-item EM instruments demonstrate comparable internal consistency and score patterns across classroom contexts? 2) do either instrument detect measurable changes in EM over a single semester? And 3) are there systematic differences in EM scores across course contexts?

Methods

Participants and setting

From January to April 2025, six instructors who had previously participated in a Fall 2024 education workshop were selected and provided a stipend to participate in this research. The instructors represented six different engineering courses across the Norm Asbjornson College of Engineering at Montana State University (Table 1).

Table 1. Courses that were involved during the spring semester of 2025.

	Dept.	*Description*	*Curricular Level*	*Enrolled students*
A	General Eng.	Multidisciplinary Engineering Design	Intermediate	123
B	Mechanical Eng. Technology	CAE Tools in Mechanical Design	Intermediate	31
C	Chemical and Biological Eng.	Process Controls	Advanced	45
D	Electrical Eng.	Intro. to Electrical Systems	Introductory	14
E	Chemical and Biological Eng.	Sustainability	Mixed	33
F	Electrical Eng.	Signals and Systems Analysis	Intermediate	23

Entrepreneurial Mindset survey data collection and analysis

In these Spring 2025 courses, students completed a combination of two survey instruments: a 28-item survey developed and validated by Li et al. (2016; Table A1) and a 34-item survey developed by Brunhaver et al. (2018; Table A2) that was validated and shown reliable in previous research (Kwapisz, Schell et al. 2022). Both instruments were administered twice during the semester through Qualtrics, once prior to a concept map activity and once after its completion. Responses were collected using a five-point Likert scale (Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree, and "I do not understand"). The surveys were covered by IRB Protocol 2024-1307 and taking the EM survey was optional. Students received a $10 Amazon gift card for completing each survey they took.

Students (N = 205) received the surveys in one of eight combinations (Table 2) and upon data collection, the surveys were first checked for missing values. The small number and percentage of missing values for each survey and order of administration likely would have had a negligible effect on analyses, but nonetheless, because a "Total Score" (i.e., the sum of all individual responses for each student) for each survey was calculated and used as the dependent variable to measure EM, these dropped values could potentially impact results. Therefore, missing values were inputted by using a mean item-response value calculated for each student. Students who responded with a "0" value indicated that they did not understand the item and therefore, "0" values were eliminated from the dataset. They were not replaced with a mean item-response value because students who responded this way indicated they had no understandable response to the survey item.

Table 2. Survey administration configurations by instrument and timing, with corresponding sample sizes (*n*).

Configuration	*Survey(s) Administered*	*Timing of Administration*	*n*
1	28-item survey only	Early semester	17
2	28-item survey only	Late semester	6
3	34-item survey only	Early semester	18
4	34-item survey only	Late semester	20
5	28-item and 34-item surveys	28-item: early; 34-item: late	55
6	28-item and 34-item surveys	34-item: early; 28-item: late	49
7	28-item survey (twice)	Early and late semester	22
8	34-item survey (twice)	Early and late semester	18

In looking at the overall "Total Scores" of the individual students, one student had a very low value for the 34-item survey that was three standard deviations below mean values and was dropped from the dataset. After these dataset modifications, a total of 349 survey responses were included in the analyses. This total comprised 28-item surveys administered first (n = 94) and second (n = 77), as well as 34-item surveys administered first (n = 85) and second (n = 93). Responses to the two administrations of the survey were analyzed using inferential statistical tests, descriptive statistics, and visual inspection of the Q–Q plots indicating approximate normality (Figure A1). Both approaches to the analyses were conducted to answer the research question whether students expressed a change from pre- to post-surveys in their attitudes and beliefs about their EM in engineering fields. The five verbal responses of the Likert scale were transformed into numerical quantities such that Strongly agree = 5, Somewhat agree = 4, Neither agree or disagree = 3, Somewhat disagree = 2, and Strongly disagree = 1.

Reliability Analyses

Reliability analyses were conducted to measure the internal consistency of the items on each survey. Student responses to the 28-item survey were combined across survey order and survey condition yielding an n = 171. Cronbach's α was calculated at 0.90, very high reliability. Student responses to the 34-item survey were combined across survey order and survey condition yielding an n =178. Cronbach's α was calculated at 0.78, moderate reliability.

Results

Test-Retest Results for Surveys Administered Twice

Paired-samples t-tests were conducted to compare mean "Total Scores" from the first and second administrations of the surveys for students who completed the same instrument twice. For the 28-item survey, there was no significant difference between the first and second administrations (Table 3). Similarly, no significant difference was observed for the 34-item survey, with mean scores of 123.0 ± 13.1 at the first administration and 123.6 ± 13.8 at the second. Internal consistency reliability, measured using Cronbach's α, was high for both instruments across administrations. For the 28-item survey, $\alpha = 0.84$ for the first administration and $\alpha = 0.86$ for the second. For the 34-item survey, $\alpha = 0.74$ and $\alpha = 0.87$ for the first and second administrations, respectively.

Table 3. Test–retest reliability and mean comparison results for surveys administered twice where "*Ad.*" indicates the first or second administration.

Survey	*n*	*Mean ± SD (Ad. 1)*	*Mean ± SD (Ad. 2)*	*t(df)*	*p*	*Cron. α (Ad. 1)*	*Cron. α (Ad. 2)*	*Test–Retest r (95% CI)*	*Shared Variance (r^2)*
28Q	22	106.3 ± 13.8	109.6 ± 11.4	1.290 (21)	0.211	0.84	0.86	0.563 [0.186, 0.796]	0.32
34Q	18	123.0 ± 13.1	123.6 ± 13.8	0.210 (17)	0.836	0.74	0.87	0.597 [0.181, 0.833]	0.36

Because the same survey was administered to the same students at two time points, test–retest reliability (coefficient of stability) was calculated using Pearson correlations of "Total Scores." The 28-item survey demonstrated a moderate test–retest correlation (r = 0.563, 95% CI [0.186, 0.796]), indicating that approximately 32% of the variability in scores was shared between administrations. Similarly, the 34-item survey yielded a moderate correlation (r = 0.597, 95% CI [0.181, 0.833]), with 36% shared variability across administrations.

Although both instruments showed some stability over time, substantial unexplained variability remained (68% and 64% for the 28- and 34-item surveys, respectively). This variability may be attributable to measurement error and/or changes in students' entrepreneurial mindset (EM) beliefs over the interval between administrations. Importantly, changes in "Total Scores" were not uniform across students (Table 4). For the 28-item survey, 2 students showed no change, 8 showed a decrease, and 12 showed an increase in Total Score. For the 34-item survey, 2 students showed no change, 6 showed a decrease, and 10 showed an increase. This wide dispersion of individual changes likely contributed to the broad confidence intervals observed for both instruments.

Table 4. Distribution of changes in "Total Score" between survey administrations for students completing the same instrument twice.

	28Q	*34Q*
Decrease	8	6
No Change	2	2
Increase	12	10

Taken together, these results suggest that while both surveys demonstrate acceptable internal consistency and moderate test–retest reliability, the observed variability over time limits conclusions regarding their sensitivity to changes in EM over the duration of a single semester.

Two Surveys Administered (Each Survey Once)

Because the two surveys had a different number of items, using "Total Score" as the dependent variable was not appropriate. A standard measure for the two surveys was derived by calculating a "Proportion Score" by dividing the "Total Score" for each survey by the total possible score for each. For the 28-item survey the total possible score was 140 and for the 34-item survey the total possible was 170. Paired-samples t-tests indicated no significant differences in "Proportion Scores" based on survey administration order (Table 5). Students who completed the 28-item survey first and the 34-item survey second, as well as those who completed the surveys in the reverse order, exhibited comparable mean scores across instruments.

Table 5. Paired-samples *t*-test results for students completing both survey instruments using the "Proportion Score" for the analysis.

Administration Order	*n*	*First Survey Mean ± SD*	*Second Survey Mean ± SD*	*t(df)*	*p*
28-item → 34-item	55	0.73 ± 0.13 (28-item)	0.74 ± 0.07 (34-item)	0.136 (54)	0.892
34-item → 28-item	49	0.72 ± 0.07 (34-item)	0.74 ± 0.09 (28-item)	0.988 (48)	0.328

28 and 34-item Surveys and Survey Administration Conditions

The purpose of this analysis was to investigate whether there were differences among the survey administration conditions for the 28 and 34-item surveys. Analyses have shown that there were no differences found when one survey was administered either first or second, when each survey was administered twice, or when each of the two surveys were administered in either survey order. Therefore, to compare survey conditions for the 28-item survey, all 28-item surveys in the one survey condition administered either first or second were combined into one condition, all 28-item surveys administered in the two surveys twice condition were combined into one, and all 28-item surveys in the two surveys each condition were combined into one. This same procedure was followed for the 34-item survey.

For both the 28-item and 34-item surveys, "Total Scores" were compared across survey administration conditions (one survey only, two surveys administered once each, and the same survey administered twice). Due to unequal sample sizes and heterogeneity of variances across conditions, Kruskal–Wallis one-way analyses of variance were conducted. For the 28-item survey, the Kruskal–Wallis test indicated a statistically significant overall difference among survey conditions ($H = 6.275$, $p = 0.043$). However, follow-up pairwise comparisons using a Bonferroni-adjusted significance level ($\alpha = 0.017$) revealed no significant differences between any conditions. For the 34-item survey, no significant differences were observed across conditions ($H = 0.056$, $p = 0.976$), and all Bonferroni-adjusted pairwise comparisons were non-significant. Taken together, these results indicate that survey administration condition did not meaningfully influence "Total Scores" for either instrument. From these results, moving forward in the research, only the 28-item survey will be used due to being slightly shorter and having more previous data available.

Classroom Differences in Total Score by Survey Type

As mentioned in the methods, there were six courses that participated in the surveys (Table 1), A through F, across three engineering disciplines and one general engineering course that multiple majors enroll in. Courses D ($n = 8$) and F ($n = 5$), both electrical engineering courses, were eliminated from these analyses because there were too few students who responded to each of the surveys. The rest of the classes were divided by which survey the students took (28 or 34-item) with the descriptive statistics shown in Table 6. Using the between-subjects variable as "course" and the dependent variable as "Total Score," an independent-samples Kruskal-Wallis one-way ANOVA, a non-parametric test, was conducted because of the unequal sample sizes and variances on both the 28 and 34-item survey results. For the 28-item survey, the test statistic of 18.4 was significant ($p < 0.001$). Pairwise comparisons with an alpha level of 0.008, which was calculated using a Bonferroni adjustment for six comparisons, showed three significant differences of courses A, B, and C all being significantly different than course E ($p < 0.001$). Similar analysis of the 34-item surveys resulted in a test statistic of 11.0 that was significant ($p = 0.012$). Pairwise comparisons with an alpha level of 0.008, showed just one significant difference of course B and E ($p < 0.009$), and two that approached significance, course B and A ($p = 0.064$) and course B and C ($p < 0.081$).

Table 6. Descriptive statistics for the "Total Score" of the 28 ($n = 166$) and 34 ($n = 170$) item survey by classroom.

Classroom	*Mean±SD 28Q*	*Number of Students 28Q*	*Mean±SD 34Q*	*Number of Students 34Q*
A – Gen Eng.	105.6±12.5	79	123.6±12.0	91
B – MET	108.8±12.7	29	130.7±9.8	21
C – ChBE	103.8±17.7	40	122.7±12.3	41
E – ChBE	90.4±12.6	18	118.8±10.7	17

As seen in Figure 1, for both surveys, the average scores trend with the same courses, B-MET > A- Gen Eng > C-ChBE (senior process controls course) > E-ChBE (multi-discipline; intermediate) confirming the previous analysis that the EM surveys measure similarly. In the case of the 28-item survey, the multi-disciplinary ChBE course focused on sustainability had significantly lower average survey scores compared to the other classes across both instruments. Unlike the Gen. Eng. course that is multi-disciplinary within engineering and typically taken by students at the junior-level, the Sustainability course counts towards students' core curriculum with the "CS" designation, indicating it fulfills the student requirement for "Contemporary Issues in Science." Therefore, students outside of the engineering disciplines enroll in the course, and it also has students ranging from freshman to seniors. Because this course serves a broader student population and is not situated exclusively within an engineering major, students' disciplinary identification and prior exposure to EM concepts may shape their responses. Although causal mechanisms cannot be established, the convergence across instruments suggests contextual sensitivity.

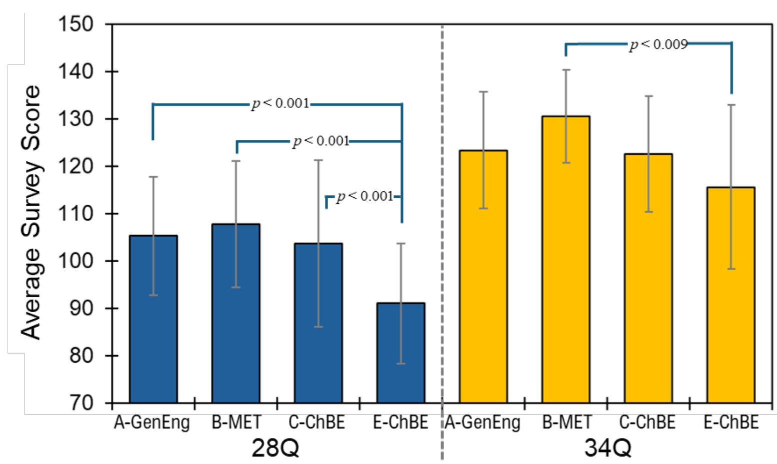

Figure 1. The average survey score for each of the courses where all 28 and 34-item surveys (pre- and post-activity) were combined. Horizontal lines above the bars represent significant differences between courses.

The MET course consistently yielded the highest EM scores across both instruments. This class deliberately integrates EM concepts throughout the semester and includes structured reflection activities explicitly tied to the 3Cs framework. It is possible that repeated exposure to EM language and explicit metacognitive prompts increased students' recognition of these constructs in themselves. Additionally, the MET student population includes a higher proportion of nontraditional students and those with prior industry experience, which may influence how they interpret and endorse EM-related items. Although these interpretations remain speculative, the consistent pattern across instruments suggests that both surveys are sensitive to curricular context and student background characteristics.

Limitations

There are several limitations with the first being the small sample size and short timeframe, second, potential instructor effects across classrooms, and third, the survey results being self-reported. Additionally, comparison to previous literature was difficult given the changing variables across the research studies.

Implications for Engineering Educators

For educators seeking to assess EM in a course setting, the 28-item instrument may be preferable due to its strong internal consistency and shorter length. However, instructors should exercise caution when interpreting pre–post survey results over a single semester, as both instruments demonstrated limited sensitivity to short-term change. Differences observed across classroom contexts suggest that survey scores may reflect broader curricular structure and student background rather than isolated interventions. Accordingly, triangulating survey data with qualitative approaches (e.g., concept mapping, structured reflection) may yield more informative insights, which will be pursued in future research.

Conclusion and Future Work

Due to the variability in the survey responses and perhaps due to the short timeframe of the administrations, there was no difference between pre- and post-survey responses for either survey. Additionally, after normalization, the survey scores from the 28 and 34-question surveys were not significantly different, indicating that although the surveys are asking different questions, they measured EM similarly. Therefore, either survey could be selected to be used to self-report EM. While no short-term changes were observed, consistent differences across course contexts suggest that both instruments are sensitive to contextual variation rather than short-term intervention effects. The interdisciplinary, core course that focused on sustainability had the lowest self-reported EM while the MET course had the highest. Potential future work should integrate more questions regarding students' background or potentially include focus groups or interviews.

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Appendix

Table A1. Survey questions for the 28-item survey. All items were answered on a 5-point Likert scale (Li et al., 2016).

Item	*Please rate how much you agree or disagree with the following statements. If the statement is unclear to you, choose "I do not understand."*
1	I have a keen sense of curiosity
2	When I see a complicated piece of machinery, I always like to find out how it works
3	I always actively seek as much information as I can in a new situation
4	I consider myself to be a person who takes action when I'm curious about something
5	I find myself being curious about a lot of things and people I encounter in life
6	I think business value creation is the company owner's concern
7	I am able to define an engineering problem in terms of value creation
8	I am able to learn from failure
9	I believe the ability to cope with failure can be improved through training
10	I am able to act effectively and creatively in difficult situations
11	I am able to use the means at my disposal to handle situations effectively
12	I have the ability to anticipate technical developments by interpreting surrounding societal trends
13	I have the ability to anticipate technical developments by interpreting surrounding economic trends
14	I pay attention to the inefficiency in the market
15	I actively think about how to correct inefficiencies
16	Creative thinking skills can be acquired through training
17	I am able to apply systems thinking to solve complex problems
18	I am able to tell if it is technically feasible to develop a new product or service
19	I am able to apply logical thinking to gathering and analyzing information
20	I am able to apply logical thinking to designing and solving problems
21	I am confident in leading a team to work on a project
22	I am able to identify potential stakeholders for a new product or service
23	I am able to address stakeholder interests in a business plan
24	My career goal is to become an excellent engineer
25	My career goal is to become an engineer with an entrepreneurial mindset
26	I have had exposure to entrepreneurship during college
27	I have had exposure to entrepreneurship before entering college
28	There is/are entrepreneur(s) among my relatives

Table A2. Survey questions for the 34-item survey. All items were answered on a 5-point Likert-scale (Brunhaver et al., 2018).

Item	*Think about your past experiences and respond by indicating how true each of the following statements are to you.*
1	I like to reimagine existing ideas
2	I like to think about ways to improve accepted solutions
3	I typically develop new ideas by improving existing solutions
4	I like to think of wild and crazy ideas
5	I tend to challenge things that are done by the book
6	Other people tell me I am good at thinking outside the box
7	I prefer to challenge adopted solutions rather than blindly accept them
8	I tend to see my ideas through even if there are setbacks
9	I look for new things to learn when I am bored
10	I am willing to consider an idea put forth by someone with a different background than my own
11	I am willing to compromise if another idea seems better than my own
12	I appreciate the value that different kinds of knowledge can bring to a project
13	I appreciate the value that individuals with different strengths bring to a team
14	I recognize that people with different backgrounds from my own might have better ideas than I do
15	I am willing to learn from others who have different areas of expertise
16	I recognize the importance of other fields even if I don't know much about them
17	I am willing to update my plans in response to new information
18	I tend to get involved in a variety of activities
19	I enjoy being involved in a variety of activities
20	I participate in a wide range of hobbies
21	The idea of tackling society's biggest problems does not motivate me
22	I believe it is important that I do things that fix problems in the world
23	I am driven to do things that improve the lives of others
24	I can easily tune into how someone else feels
25	Other people tell me I am good at understanding their feelings
26	I know when I need to ask for help
27	I am comfortable asking others for help
28	I prefer what I am used to rather than what is unfamiliar
29	I would rather work with what is familiar than what is unfamiliar
30	I am less likely to change directions on a project after putting forth a lot of effort
31	I tend to resist change
32	I like to work on problems that have clear solutions
33	I prefer tasks that are well-defined
34	I tend not to do something when I am unsure of the outcome

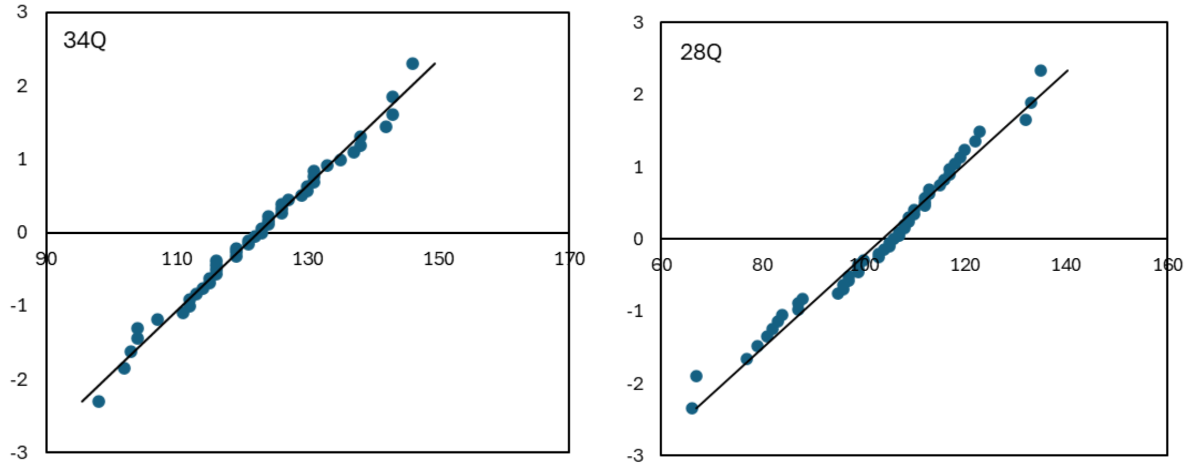

Figure A1. Q–Q plots assessing normality of total entrepreneurial mindset (EM) scores for the 34Q (left) and 28Q (right) instruments.