Soft Skills Curriculum on a Budget: Tackling the STEM skills gap with limited resources using online video

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Abstract

Employers seek employees who can communicate clearly with others from different backgrounds, solve problems in a team structure, and embrace leadership roles. However, there is often a skill gap between what employers need and what their potential employees provide. Many employers are finding recent college graduates lacking in soft skills such as problem solving, critical thinking, and communication, yet these are considered essential for success in the workplace.

As part of an NSF S-STEM grant, the University of Wisconsin - Platteville implemented a series of professional development opportunities to STEM Master Students on a variety of topics. In asking students about topics they wanted, students reported a need for soft skills. Knowing the students desire to learn about soft skills and knowing that employers find soft skills essential, the team wanted to determine how effective incorporating professional development opportunities, called "Scholar Spots," to the scholarship program were at increasing the student's ability in the topic areas.

The team decided to advance students' learning about soft skills through a series of monthly webinars, dubbed "Scholar Spots." Each spot was required viewing for students in the scholarship program and was hosted by a subject matter expert on the chosen topic.
Each spot ran for an hour—with the first forty-five minutes dedicated to the main subject and the remainder reserved for questions by the viewers. These spots were recorded and then segmented into smaller five to ten-minute videos, which were then edited, refined and uploaded to our YouTube channel (https://www.youtube.com/channel/UC3nI8qyyPDMM3y_nVxdlFJg), available as online resources to be viewed by all.

Participants were asked a series of pre- and post-test questions about their abilities in relation to the soft skill spots presented throughout the year. Additionally, participants were asked specific questions to show their ability gains regarding the various topics. The team reviewed the collected data using both qualitative and quantitative methods.

While measuring a change in soft skills is not possible with existing validated instruments [1], [2], qualitative data showed a positive impact. The University of Wisconsin-Platteville found that this was a low-cost benefit to students as it added the necessary soft skill curriculum to the student's academic program without adding courses. Students agreed that attending the spots was not overly burdensome. Most agreed that they learned something to incorporate into their employment practices.

Introduction

While the most strident narrative from STEM employers is that there are not enough STEM graduates to fill open positions, the full picture is somewhat more complex. Success in the modern workplace requires that STEM employees possess more than just technical skills. Soft skills, 21st century skills, or professional skills such as teamwork, communication, creative

problem solving, and leadership are in as much or more demand from STEM employees as their technical know-how. Unfortunately, there is often a skill gap between what employers need and what their newly-graduated job candidates can provide. Perhaps this problem is defined less by a lack STEM graduates, than by an employee pool which lacks the desired soft skills.

Furthermore, both employers and policymakers have been pressuring universities to improve student outcomes such as time to graduation, while also focusing on added soft skill development. However, higher education institution budgets are being squeezed on all sides and are under more scrutiny than ever. Currently, state funding for public colleges and universities is lower than before the 2008 recession [3]. At the same time, tuition freezes and caps are being added to limit the strain of ever-increasing student debt. Public universities need flexible low-cost tools to teach students soft skills without adding extra expense or time to their education.

To address the need for graduates with stronger soft skills within today's budgetary constraints and academic performance metrics, the University of Wisconsin-Platteville developed and offered a series of professional development opportunities to STEM Master Students as part of a NSF-funded grant project. During the planning phase, the team reached out to students regarding topic preferences and found that students wanted to improve their soft skills. With student and employer interests aligned, the team set out to determine how effective the incorporation of professional development opportunities into the scholarship program were at increasing the students' soft skills.

With this information and background, the team proposed that each STEM student participant describe how effective the one-hour professional development webinars were in improving their own soft skills ability. The researchers believe that the exposure to these skills will raise awareness and motivate students to improve and develop their soft skills. This awareness helps students more accurately self-assess their own soft skills abilities.

Literature Review

Soft skills include communication, teamwork, conflict management, emotional intelligence, and cultural competency, among others. These are sometimes referred to as "professional skills" or "21st century skills." The National Research Council's [4] Committee on Defining Deeper Learning and 21st Century Skills identified three categories: cognitive, intrapersonal, and interpersonal.

Research shows that these soft skills are desperately needed in the STEM workforce. STEM occupations are becoming increasingly interdisciplinary [5], [6], [7]. Meanwhile, machines are increasingly performing routine tasks in the workforce, which makes human skills and teamwork more valuable [8]. Universities must ensure that graduates have learned the necessary soft skills to succeed in the modern workforce.

Since 1980, both the number of occupations and the wages for jobs that require interpersonal skills have grown more than jobs that require technical STEM skills alone [8]. Surveys consistently find that employers seek employees who can communicate clearly with others from different backgrounds, solve problems in a team structure, and embrace leadership roles [9], [10]. The teams that possess these soft skills can be more effective than those who do not, as

Google learned in their 2017 Project Aristotle. The project found that Google's most productive ideas came from teams that did not have the top specialists but used soft skills in their teamwork [11].

However, there is a skills gap between what employers need and what their potential employees provide [9], [12]. Studies indicate that the STEM employee pool lacks desired soft skills [9]. For example, according to the National Association of Colleges and Employers, only 42% of employers rated recent college graduates as proficient in communication [13], but employers considered this an essential skill [14].

Ample previous research has shown that videos can effectively enhance learning in formal environments [15], [16], [17], [18], [19], [20]. Educational videos in the classroom increase enthusiasm and enhance comprehension, especially among groups with diverse learning styles [21]. Such videos have also been shown to improve motivation [21], [18], [20]. Recent literature confirms YouTube videos specifically can effectively contribute to formal education in chemistry [22]. Moreover, because soft skills can be difficult to teach in classroom settings, videos are particularly conducive to soft skill education [23].

Program Background

In 2015, the University of Wisconsin – Platteville received a five-year NSF S-STEM grant to increase the number of individuals graduating with a Master of Science in a STEM related field (which includes Engineering, Project Management and Integrated Supply Chain Management). As part of the grant, the students receiving scholarships were required to attend one-hour professional development spots, called "Scholar Spots." These spots were on a variety of topics relating from leadership to career planning to soft skills. Feedback from the students showed the students valued the Scholar Spots related to soft skills. Knowing the Soft skills are a growing need within STEM disciplines, the team initiated research to determine the effect these spots had on a STEM student's soft skill ability.

The team worked with four subject matter experts (SMEs) in four soft skills defined areas—oral communication, written communication, active listening, and team or group work. The SMEs are recognized leaders—professionally or academically—in the topic areas. The SMEs each hosted a one-hour live webinar about one of the four topics. The webinar lasted approximately forty-five minutes with fifteen minutes for question and answers. The spots were hosted monthly throughout the academic year using Blackboard Ultra Collaborate in a Canvas course shell. All spots were recorded for students who were not able to attend the live session. However, attendance at these spots averaged at 30% with most students attending group work, Active Listening, and Oral Communication.

The team sought SMEs who would host the spot as a donation of time to keep costs low. The team learned that some spots, such as the group work spot, did cost a minimal fee due to using a specific curriculum. However, most SMEs were willing to host a spot at no cost.

Research Methodology

To obtain information about how the spots impacted the STEM students, the team developed a multi-prong, mixed methods approach to gather the necessary information. The team used both pre/post-test methodology combined with reflection activities that provided qualitative data.

Canvas assignments were used to collect the reflective activity responses for each scholar spot which were downloaded for the team to look at for themes of how the scholars viewed the impact of the topic. At least one member of the team attended each spot in order to observe the scholar's interaction with the SMEs. Observers were asked to perform assessments for each spot for the grant; assessment data included observations such as number and types of questions asked which was considered in the initial data analysis but was not used in the final analysis.

Pre/post-test. All students within the Scholarship program were asked to complete a pre-test on their soft skills ability in four areas including writing skills, oral communication, group or teamwork, and listening skills. At the end of the series of scholar spots, students were asked to complete a post-test containing the same questions asked on the pre-test to determine if they noticed a change in their skills or abilities. A copy of the pre/post-test questions can be found in the Appendix A.

These pre/post tests used a Canvas quiz feature to ensure that pre and post test results could be aligned. Names and identifying information were removed from the analysis to eliminate bias.

Reflection activities. Each scholar spot was offered after the pre-test was designed by an SME who was given information about the questions asked of the students as well as background information regarding the research design. After each scholar spot was offered, students were asked to perform a short activity relating to the scholar spot.

- Active Listening. After the active listening scholar spot, students were asked to do three activities including: 1. Restate one concept from the presentation, 2. Think about a time when listening stopped and how they would avoid this in the future, and 3. Attempt to implement one of the six strategies discussed and reflect on the experience after a week. The researchers were able to use the answer to the third question to triangulate information on the pre/post test (more details are found in the Analysis and Results section).
- Oral Communication. After the oral communication scholar spot, students were asked to apply a rubric to the presenters' spot. The students were also asked to reflect on a presentation they were involved with giving using a prescribed rubric. Researchers attempted to see a correlation between the self-reflection and the pre/post test; however, the rubric did not provide any data on why scores were selected which limited the correlation.
- Written. For the written scholar spot, students were asked to revise a document that had been previously submitted using the concepts learned in the scholar spot. Students did revise the documents. As researchers reviewed the revisions, it became clear that the results of the changes were subjective to individual writing styles.
- Group/Team Work. The group/team work scholar spot used the Clifton Strengths Finders to show how strengths can be used in groups. This was the final scholar spot.

Students were asked to submit their strengths; however, researchers realized more reflection was needed.

As the team analyzed the data received, including the pre/post test results, the team saw a need to get more insight from the students. The team developed an online interview tool to gain additional insight into each topic area. For each of the four topics, students were asked for each topic area the following questions:

- Provide one to two examples of how your <insert topic area from above> abilities have changed as a result of attending.
- What is one area within <insert topic area from above> that you still wish to improve and why?
- Would you recommend the <insert topic area from above> presentation to a colleague? Explain why in 2-3 sentences.

Analysis and Results

Each team member analyzed the qualitative data individually and later as a team to share identified themes. While this was occurring, the quantitative data collected from the pre/post test was being processed to determine a change in perception. After all data was analyzed, the team reviewed the analysis results to draw conclusions and recommendations. While a sample size of 17 is small for a quantitative methodology, qualitative methods show sample sizes of approximately 20 are valid [24, p. 157].

Overall, of the 17 students who completed both the pre and post test, most (7) stated no change in their confidence of their soft skills abilities. Of the remaining 10 students, 6 saw their confidence increase while 4 saw their confidence decrease. However, when looking at the topics individually, the confidence within a topic varied (Table 1).

Table 1. Change from pre-test to post-test about a student's ability in the each topic area.

	Decrease	No Change	Increase
Team Work	9	1	7
Oral Communication	3	2	12
Active Listening	6	3	8
Written Communication	8	7	2
Overall	4	7	6

A post-hoc power analysis with n = 17 was performed using G*Power software to determine the probability of making a type II error (Tables 2-7). The effect size was calculated in G*Power based on the pre and post means, standard deviations, and correlation coefficients (Table 8). The post-hoc power analysis for comfort with soft skills yielded power = 0.27, which is very low and indicates the probability of making a type II error is very high at 0.73. This means there is a 73%

chance that the null hypothesis was not rejected when it was false. For confidence using various tools to communicate (table 3) and ability to actively listen (table 4), the power was very high at 0.916 and 0.996, respectively. Therefore, the probability of making a type II error was very low for both of these measures. For ability to speak (table 5), the power was 0.51, so there was an 49% chance of making a type II error.

Table 2. G*Power results for confidence with soft skills abilities.
t tests - Means: Difference between two dependent means (matched pairs)
Analysis: Post hoc: Compute achieved power
Input:	Tail(s)	=	Two
	Effect size dz	=	0.3150586
	α err prob	=	0.05
	Total sample size	=	17
Output:	Noncentrality parameter δ	=	1.2990199
	Critical t	=	2.1199053
	Df	=	16
	Power (1-β err prob)	=	0.2309587

Table 3. G*Power results for confidence using various tools to communicate.
t tests - Means: Difference between two dependent means (matched pairs)
Analysis: Post hoc: Compute achieved power
Input:	Tail(s)	=	Two
	Effect size dz	=	1.1172489
	α err prob	=	0.05
	Total sample size	=	17
Output:	Noncentrality parameter δ	=	4.6065352
	Critical t	=	2.1199053
	Df	=	16
	Power (1-β err prob)	=	0.9907565

Table 4. G*Power results for confidence in my ability to actively listen.
t tests - Means: Difference between two dependent means (matched pairs)
Analysis: Post hoc: Compute achieved power
Input:	Tail(s)	=	Two
	Effect size dz	=	1.4254807
	α err prob	=	0.05
	Total sample size	=	17
Output:	Noncentrality parameter δ	=	5.8774075
	Critical t	=	2.1199053
	Df	=	16
	Power (1-β err prob)	=	0.9997984

Table 5. G*Power results for confidence in my ability to speak.
t tests - Means: Difference between two dependent means (matched pairs)
Analysis: Post hoc: Compute achieved power
Input:	Tail(s)	=	Two

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                    Effect size dz              =  0.3543058
                    α err prob                  =  0.05
                    Total sample size           =  17
Output:             Noncentrality parameter δ   =  1.4608402
                    Critical t                  =  2.1199053
                    Df                          =  16
                    Power (1-β err prob)        =  0.2793162
```

Table 6. G*Power results for confidence when working in at team.
t tests - Means: Difference between two dependent means (matched pairs)
Analysis: Post hoc: Compute achieved power
```
Input:              Tail(s)                     =  Two
                    Effect size dz              =  0.4948793
                    α err prob                  =  0.05
                    Total sample size           =  17
Output:             Noncentrality parameter δ   =  2.0404396
                    Critical t                  =  2.1199053
                    Df                          =  16
                    Power (1-β err prob)        =  0.4831389
```

Table 7. G*Power results for confidence in my ability to write.
t tests - Means: Difference between two dependent means (matched pairs)
Analysis: Post hoc: Compute achieved power
```
Input:              Tail(s)                     =  Two
                    Effect size dz              =  0.4718243
                    α err prob                  =  0.05
                    Total sample size           =  17
Output:             Noncentrality parameter δ   =  1.9453814
                    Critical t                  =  2.1199053
                    Df                          =  16
                    Power (1-β err prob)        =  0.4477529
```

Table 8.

	Confidence with soft skills abilities		Confidence using various tools to communicate		Confidence in ability to actively listen		Confidence in my ability to speak	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	3.1176	2.8235	2.8824	3.3529	1.8235	3.0588	2.7059	3.0588
Standard Deviation	0.8319	0.7059	0.5823	0.6809	0.6169	0.8022	1.1254	0.8725
Pearson Correlation Coefficient	-0.0648		0.5498		-0.2167		0.6766	

Active Listening. When analyzing the qualitative data received from the Active Listening scholar spot, it was noted by one student that "It's hard to remember to practice active listening..." Another student stated that "…active listening strategies helped me better connect…(though) it

might take me a while to integrate (the strategies)." When aligning the comments with the pre/post-test information it was noted that students' perceptions changed and that the change aligned with their comments.

When asked several months after the spot to reflect on the active listening, students reflected that this spot was "…helpful, but …a lot of information…" and "informative and can be easily applied to any person…"

Oral Communication. The rubric students used to critique a presentation did not provide data that could be analyzed to see if the spot was beneficial. However, when the team asked for clarifying information, students noted they used the information presented. As one student stated, "I took his advice to bring a set of notes to go off during presentation and it has helped me speak in front of large groups." Overall, students found this session beneficial and would recommend it to peers.

Written Communication. After the written communication spot, students were asked to revise a goals document they had previously submitted to their mentors using the information presented in the spot. When the team compared the two writing examples, it was determined that one could not easily determine if the concepts were applied as writing styles are subjective to each individual. It was evident that most students made changes to their documents. However, without additional insight into why the changes were made, the team could not determine if the spot was effective.

When reflecting on the spot at a later date, the students had mixed reviews. One student stated, "One review session is not nearly as in-depth as a full English class (which I highly recommend)." While another student stated, "It's very helpful to learn more about ways to improve your written communication." However, nearly all of the students stated they had at least one area in which they would like to improve.

Group Work. The final spot about group work used the Clifton Strengths Finder Assessment so students could learn about their individual strengths in relation to a group. While the students did not have workgroups to compare their results to, the students were provided information on how to use their strengths. Initial data collected from this spot included the strengths of each individual. However, this did not provide information on whether the spot was effective.

When asked to later reflect on the spot, students noted that "The strengths presentation was very good for self-reflection. It also allowed for greater knowledge of how others may present their strengths and how to notice and leverage them" and "It is much easier to get things accomplished as a team if everyone operates in their strengths. Knowing your own strengths also helps you accept and decline opportunities with confidence."

While the reflection shows positive results for the spot, no conclusion could be drawn about the effectiveness.

Triangulation. When reviewing the quantitative analysis to the qualitative findings, both the active listening spot and oral communication spot show a strong correlation that the additional

professional development provided through the Scholar Spots did have an impact on the student's perceived abilities and knowledge.

Conclusion and Recommendations

Even though it is difficult to measure how effective soft skills professional development is due to the lack of reliable measuring instruments, the team did see that the low-cost method of holding one-hour webinars did have an impact on the student's self-perceptions of their soft skills abilities. The documented responses from students indicated that they were able to improve their active listening skills, become comfortable talking in front of large groups, and use their strengths in group work. With the positive findings, the team recommends using such low-cost methods since they can have an impact.

Moving forward, the team recommends that STEM students attend professional development opportunities that occur outside of the classroom. This could include conferences, webinars, or in-person opportunities. Based on student feedback, the reflection activities helped participants get more out of such professional development sessions. The team recommends incorporating reflection activities and knowledge application into student professional development.

Additionally, it should be noted that expected outcomes and benefits will vary by student and topic. Some students will find great value in one topic while other students will not find the same value. Awareness of this ahead of time can help students determine which sessions will be most beneficial to them based on their desired needs.

Finally, results will not be immediate. As with any skill, practice is essential to grow and maintain the skill sets learned. Students will need to reflect on their implementation of the skills in order to see the changes. Changes may be observed after several months of implementation. In addition to reflection on personal skills, students may need to ask peers if they notice a change in behavior.

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Appendix A: Pre/Post Test

Please assess what you believe to be your skill level on the following items:
(scale 1-rarely, 2-sometimes, 3usually, 4-always)
I am confident with my soft skills ability.
I am confident using various tools to communicate.
I face the person who is talking
I notice the feelings behind the words.
I ask questions to get more information and encourage the speaker to continue.
I watch for significant body language.
I repeat in my own words what I've just heard to ensure understanding.
I interrupt the speaker to make a point.
I find myself thinking about other things while the person is talking.
I am distracted by other demands on my time.
I am confident with my ability to actively listen. (scale 1-rarely, 2-sometimes, 3usually, 4-always)
I can use appropriate body language while having a conversation
I can ask complex questions to get the appropriate information.
I communicate with others to resolve conflicts or other problems.
I can express my opinions and ideas clearly and concisely.
I can restate information that is presented orally.
I can give clear instructions.

I can give a brief presentation to a small group.
I can explain difficult subject matter using detailed examples.
I can give presentations to large, unfamiliar groups.
I am confident in my ability to speak..
As a team member, I encourage others in the team to look at our work from different perspectives.
If something is unclear, I ask questions of the team.
As a team member, I address conflict constructively.
I treat everyone in the group with respect.
As a team member, I work hard on my contributions to the group effort.
I contribute to the team.
I am a team player, working well with others.
I treat other team members with courtesy and consideration all of the time.
I know how to follow and take directions well and can be as flexible as needed.
I am dependable and reliable. People can count on me to get the job done.
I am confident when working in a team.
Before sending written messages, I make sure I gather all of the facts.
Before sending written messages, I take time to think about what my audience wants and needs and how my audience will respond.
When writing, I make certain the tone is positive (when appropriate).
When sending a written message, I reread the message to make sure everything is correct.
Before sending written messages, I check the message for logical consistency.
Before sending written messages, I ensure the tone is other-oriented.
I am confident in my ability to write.
I am confident with my soft skills ability.