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Milan Toma
New York Institute of Technology, USA

Faiz Syed
New York Institute of Technology, USA

Lise McCoy
New York Institute of Technology, USA

Michael Nizich
New York Institute of Technology, USA

William Blazey
New York Institute of Technology, USA

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Engineering in Medicine: Bridging the Cognitive and Emotional Distance between Medical and Non-Medical Students

Milan Toma, Faiz Syed, Lise McCoy, Michael Nizich, William Blazey

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Abstract

In the current study, we focused on measuring the development of important professional attitudes, such as "*compassion satisfaction*" and "*burnout*". Students from four different colleges worked in teams to conceptualize innovative engineering products. During the ideation phase of their project, participants completed a Professional Quality of Life survey to assess metrics related to *compassion satisfaction* and *burnout*. On average, the combined *compassion satisfaction* score was high for both medical students (42/50) and non-medical students (43/50). In terms of *burnout*, 77% of medical students and 81% of non-medical students reported low *burnout*; the average *burnout* score for medical students was 19/50, and for non-medical students 17/50. Only one statement produced a statistically significant difference between groups. For the statement, "I am a caring person", only 31% of medical students self-described as being a very caring person 'very often' as opposed to 62% of non-medical students. Through this innovative curriculum project, faculty were able to measure the level of student *compassion satisfaction*, and *burnout* for the students involved. Surrounded by the rationality of science, students learned to communicate and contribute to projects that supported a positive sense of contribution and effort, and a low perception of *burnout*.

Introduction

Medical language is used to exchange medical information quickly and accurately. Medical professionals know what they are saying to each other; it is easier, and it saves time. However, when explaining something to their patients, they attempt to switch to simpler terms that people not used to dealing with medical problems and techniques can understand. That is variably successful; often they might think that they did explain something well, but later it turns out that the patients did not understand some or all of it, and even left with wrong ideas. Hence, it is imperative that medical professionals learn how to communicate with laypersons as soon as possible in their training.

To explore how preclinical medical students experience elements of their training, specifically their pursuit of

medical knowledge and how this may impact their attributes as well as their relations with those outside of the realm of medicine, Michalec interviewed students at a medical school regarding their experiences with and perceptions of their medical training (Michalec, 2012). The students reported a cognitive and emotional distance from non-medical students that appears to be accentuated not only by their strenuous academic responsibilities but also by elements of the hidden curriculum nested within medical training. Furthermore, students discussed experiencing disapproval, mistrust, and negative judgment toward laypersons, thereby suggesting that this distancing may lend to deleterious effects on students' ability and willingness to connect with others. Hence, in the present study we attempted to bridge the reported cognitive and emotional distance between the medical and non-medical (engineering) students by introducing them to engineering projects based on voluntary participation.

Engineering in medicine is becoming more of a pronounced theme in today's academic and industrial society. The field of engineering offers more potential significance to medical evolution. Many medical schools have had created centers for engineering in medicine to work at the convergence of engineering, science, and translational medicine (e.g., Institute for Medical Engineering and Science at MIT). These centers often include multi-institutional programs supporting research that addresses unmet clinical needs with a path toward developing commercial products and accelerating the commercialization of early-stage medical technologies.

Convolving Engineering and Medical Pedagogies

Strong interest is indicated by both medical and non-medical students, but when given the opportunity only less than half collaborate, according to a study conducted by Brazile et al. (2018). Moreover, they found that medical students felt their curriculum inadequately addressed creativity and innovation relative to their engineering counterparts. The medical students also felt less prepared for entrepreneurial activities, while engineering students indicated a need for basic medical knowledge and patient-oriented design factors. Others have too expressed the need for convolving engineering and medical pedagogies (Lee, 2013). Future biomedical engineers and medical doctors must be able to predict clinical responses to therapeutic interventions. Medical education needs to involve engineering pedagogies, teaching basic governing rules of complex system behavior, and developing skill sets in manipulating these systems. Similarly, graduate biomedical engineering programs need to include more practical exposure to clinical problem solving. It is recognized that the complexity of medical problems requires collaborative efforts from individuals having diverse training and expertise. Various approaches can facilitate interdisciplinary interactions. Training graduate students in isolation within single disciplines is detrimental. However, at the same time, it is not realistic to expect from any one individual to learn all the essentials from all the disciplines involved. What can be done is training students to incorporate research and development in interdisciplinary teams (Humphrey et al, 2005).

A similar study describing the lessons learned since the establishment of a health, technology, and engineering program was published by Tolomiczenko and Sanger (2015). They recruited twelve students from schools of Engineering and Medicine to learn about and participate in all phases of medical device development. The students' levels of motivation and commitment were assessed. In Japan, working engineering professionals were admitted to a re-education program consisting of interactive, modular, and disease-based lectures (case studies)

as well as substantial laboratory work. Matsuki et al. (2009) published their findings on "the effects of unique biomedical education programs for engineers".

Interprofessional Education

It is accepted that interprofessional education is an integral feature of health education programs. Almost all healthcare students agree that interprofessional workshops enhance their understanding of the role and expertise of other healthcare professionals (Bereznicki et al, 2021). However, it comes with many challenges, such as adequate curriculum space (Moote et al, 2021), funding (Diggele et al, 2020), and faculty training (Chitsulo, Chirwa, & Wilson, 2021). Creating authentic interprofessional activities for health professional students includes early training and experiences from collaborating between healthcare teams. Homberg and Stock-Shroer (2021) explored the question of what should be considered in undergraduate interprofessional training on complementary and integrative medicine for students of medicine and other healthcare professions and what benefits can be expected. However, especially in research and development, typical collaborations include more than healthcare teams. Collaborating with professionals with skill sets and expertise outside healthcare is also integral for training medical students, i.e., multiprofessional education. Though, findings demonstrate that both interprofessional and multiprofessional education approaches achieve different education objectives (Goldman et al, 2021). Overall, improved leadership, collaboration and communication between all teams involved, ultimately yield improved patient safety.

Burnout in Medicine

Burnout is a common problem among healthcare professionals. Studies indicate that approximately 1 of every 3 physicians is experiencing burnout at any given time (Shanafelt et al, 2002). It is identified by emotional exhaustion, depersonalization, and having a sense of low personal accomplishment (Shanafelt, Sloan, & Haberman, 2003}. This problem represents a public health crisis with negative impacts on individual physicians, patients and healthcare organizations and systems (West, Dyrbye, & Shanafelt, 2018). Multidisciplinary actions that include changes in the work environmental factors along with stress management programs that teach people how to cope better with stressful events showed promising solutions to manage burnout (Romani & Ashkar, 2014). Participation in a mindful communication program was associated with short-term and sustained improvements in well-being and attitudes associated with patient-centered care (Krasner et al, 2009).

Method

To improve the students' ability and willingness to connect with others, medical students at the College of Osteopathic Medicine (NYITCOM) work in teams with the Science, Technology, Engineering, the Arts, and Mathematics (STEAM) students from College of Engineering and Computing Sciences (NYIT-CoECS), College of Arts and Sciences (NYIT-CoAS) and School of Architecture and Design (NYIT-SoAD). All these colleges are on the same New York Tech campus. Hence, the potential to contribute to the medical evolution by facilitating interprofessional collaboration between New York Tech's colleges is explored.

Understanding the positive and negative aspects of helping others can improve the students' ability to help them and, consequently, the ability to keep their focus on the task. Hence, Professional Quality of Life (ProQOL Version 5) (Stamm, 2016) questionnaire was used to measure the students' understanding of what helping others means to them. *Compassion satisfaction*, *secondary traumatic stress*, and *burnout* are measured with ProQOL. It has three independent sub-scales and has been culturally adapted for use in several countries. Many studies, e.g. with nurses, have utilized the sub-scales of the ProQOL tool to measure *compassion satisfaction*, *secondary traumatic stress*, and *burnout* independently (Higgins et al, 2020; Wijdenes, Badger, & Sheppard, 2019; Polat, Turan, & Tan, 2020; Zakeri et al, 2021; Galiana et al, 2020).

The tool comprises of 30 items, 10 items each on *compassion satisfaction*, *secondary traumatic stress*, and *burnout*, and each item is rated on a five-point Likert scale ranging from "never" (1) to "very often" (5). The total score range is 10 – 50; scores are classified as low (≤ 22), moderate (23 – 41), and high (≥ 42). The higher scores indicate higher *compassion satisfaction*, *secondary traumatic stress*, and *burnout*. As suggested by the developer, the total score was standardized to a t-score with a mean of 50 ± 10. The standardized scores were classified as low (< 25%), moderate (25% – 74%), and high (≥ 75%), with higher scores indicating a higher frequency of *compassion satisfaction*, *secondary traumatic stress*, and *burnout*.

For this study, the questions used to measure the *secondary traumatic stress* are omitted. Those questions are related to secondary exposure to extremely or traumatically stressful events, which do not apply to the projects usually undertaken in the university setting by the non-medical students together with the medical students. Hence, for the purpose of this study, only two out of the three sub-scales are measured, i.e., the *compassion satisfaction* and *burnout*. The ProQOL defines *compassion satisfaction* as follows. "*Compassion satisfaction* is about the pleasure you derive from being able to do your work well. For example, you may feel like it is a pleasure to help others through your work. You may feel positively about your colleagues or your ability to contribute to the work setting or even the greater good of society. Higher scores on this scale represent a greater satisfaction related to your ability to be an effective caregiver in your job. If you are in the higher range, you probably derive a good deal of professional satisfaction from your position. If your scores are below 23, you may either find problems with your job, or there may be some other reason—for example, you might derive your satisfaction from activities other than your job." Alpha scale reliability for *compassion satisfaction* is 0.88.

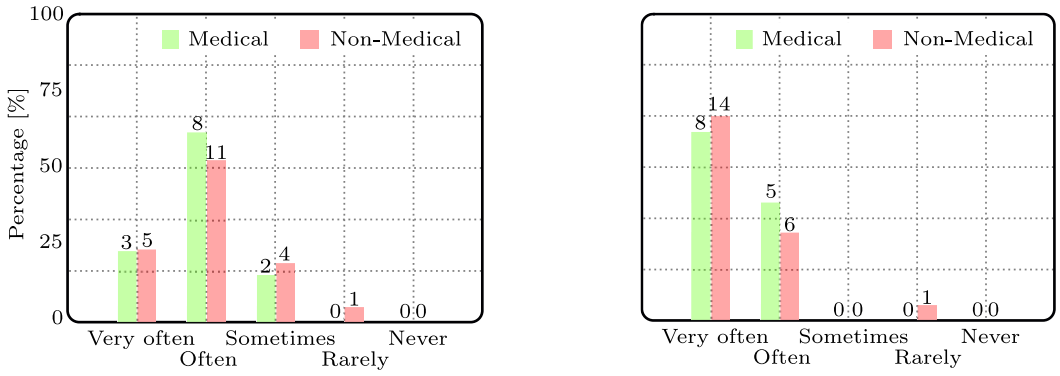
Similarly, *burnout* is described in ProQOL as follows. "Most people have an intuitive idea of what *burnout* is. From the research perspective, *burnout* is one of the elements of compassion fatigue. It is associated with feelings of hopelessness and difficulties in dealing with work or in doing your job effectively. These negative feelings usually have a gradual onset. They can reflect the feeling that your efforts make no difference, or they can be associated with a very high workload or a non-supportive work environment. Higher scores on this scale mean that you are at higher risk for *burnout*. If your score is below 23, this probably reflects positive feelings about your ability to be effective in your work. If you score above 41, you may wish to think about what at work makes you feel like you are not effective in your position. Your score may reflect your mood; perhaps you were having a "bad day" or need some time off. If the high score persists or if it is reflective of other worries, it may be a cause for concern." Alpha scale reliability for *burnout* is 0.75.

Results

In total, 34 students from all colleges participating in the program responded to the ProQOL questionnaire. Of the 34 students, 11 were from the College of Osteopathic Medicine, 17 from the College of Arts and Sciences, and 6 from the College of Engineering and Computing Sciences. Of the 17 students from the College of Arts and Sciences, 2 were in their premedical B.S./D.O. program. Hence, those 2 will be treated as medical students for the purpose of this study. Therefore, of the 34 participants, 13 were with medical background and 21 with various STEM backgrounds. They self-ascribed their own field of expertise as follows: medicine, mechanical engineering, life sciences, biomedical engineering, architecture design, biology, computer programming, tissue engineering, cybersecurity. The students were randomly grouped together. Each group had to have at least one student with a medical background. However, every group had eventually requested to include at least two medical students.

At the time when the questionnaire was given to them, of the 34 participants, 53% of them had already established a concept/idea to which they decided to dedicate their time together, whereas the rest were still discussing on what ideas to work. An assumption was made that the degree to which they have progressed at that point was not important for the purpose of this study. The purpose here was to simply observe how the diversity of individuals working together, regardless of their progress, influenced their professional quality of life.

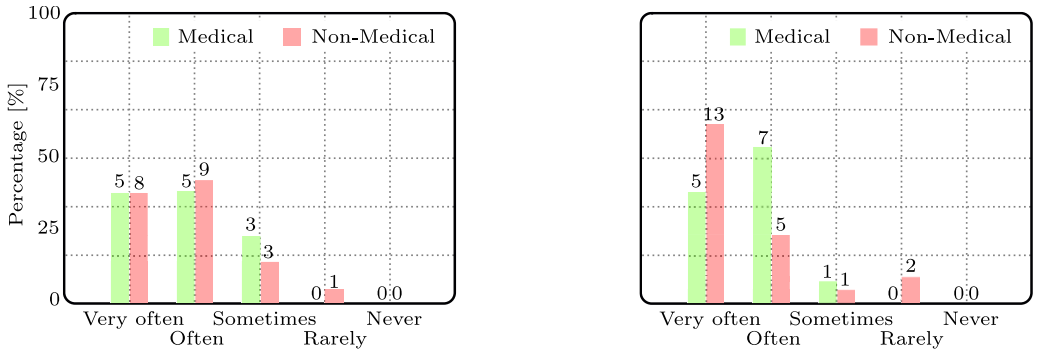
Of the 34 participants, 8 responded that they were ‘very often’ happy, 19 were ‘often’ happy, 6 ‘sometimes’, and 1 ‘rarely’. However, when divided between medical and non-medical students, 85% of medical students were either ‘very often’ or ‘often’ happy, compared to 76% of non-medical students (Fig. 1(a)). Almost everyone in both the groups, medical and non-medical, felt satisfied having the possibility to help people (Fig. 1(b)), which they were provided through this program.



(a) Statement 1 (b) Statement 2

Figure 1. Statement 1: ‘I am happy’. Statement 2: ‘I get satisfaction from being able to help people’.

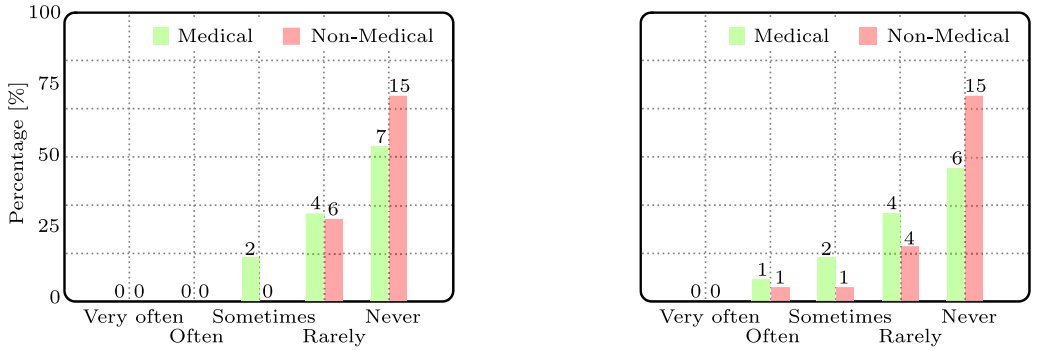
When the question is more of a general kind, such as ‘I feel connected to others in my life’, the answers provided by both the groups, medical versus non-medical, are similar (Fig. 2(a)). However, when asked if they felt invigorated after working for those they help, and therefore they could connect the question more with the project on which the non-medical students collaborated with the medical students, 65% of the non-medical students answered ‘very often’ as opposed to 38.5% of medical students (Fig. 2(b)).



(a) Statement 3 (b) Statement 4

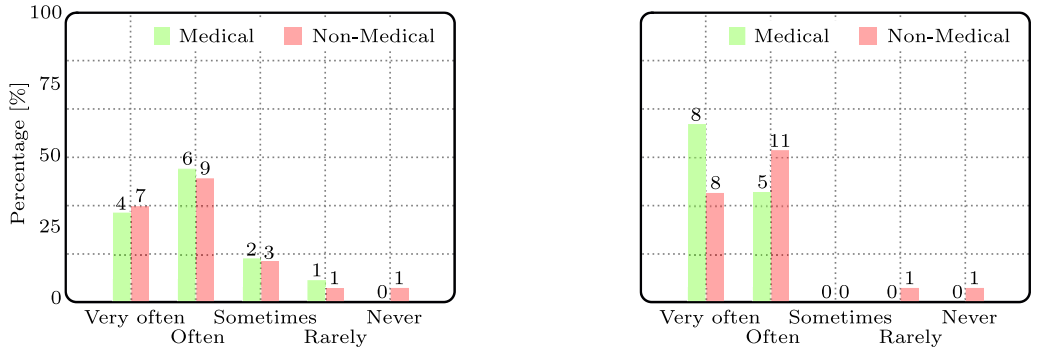
Figure 2. Statement 3: 'I feel connected to others in my life'. Statement 4: 'I feel invigorated after working for those I help'.

When asked to rate the statement, 'I am not as productive at my project because I am losing sleep over traumatic experiences of the people I help' (Fig. 3(a)), it was more common of the medical students to answer 'sometimes' or 'rarely' (46%), as opposed to 'never' (54%). Whereas 71% of the non-medical students said 'never'. Similarly, only 46% of the medical students answered that they never felt trapped by their project as helper. On the other hand, 71% of the non-medical students claimed they never felt trapped (Fig. 3(b)).



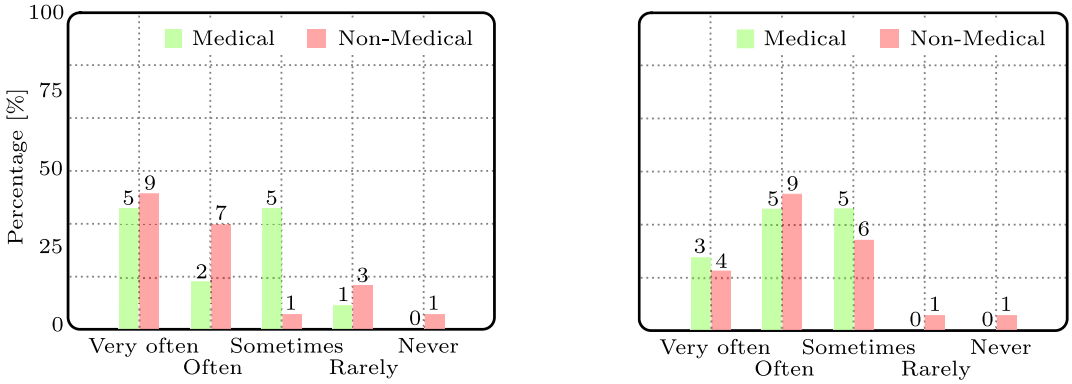
(a) Statement 5 (b) Statement 6

Figure 3. Statement 5: 'I am not as productive at my project because I am losing sleep over traumatic experiences of the people I help'. Statement 6: 'I feel trapped by my project as a helper'.



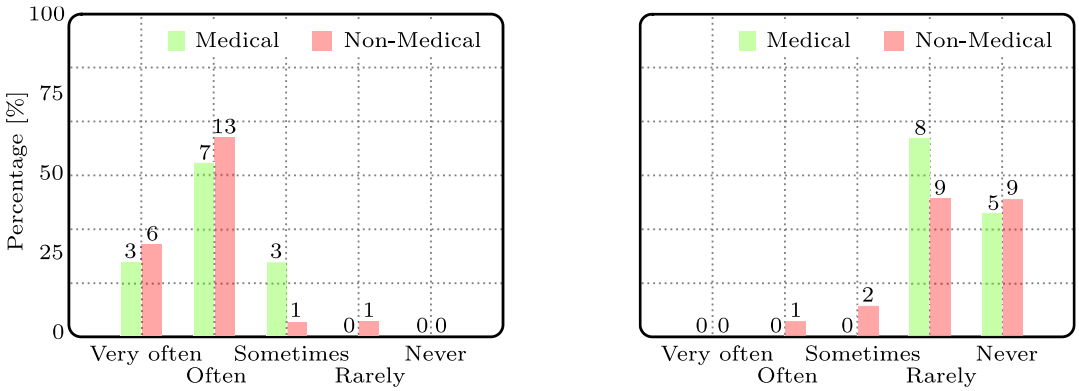
(a) Statement 7 (b) Statement 8

Figure 4. Statement 7: 'I like my work as a helper'. Statement 8: 'I have beliefs that sustain me'.



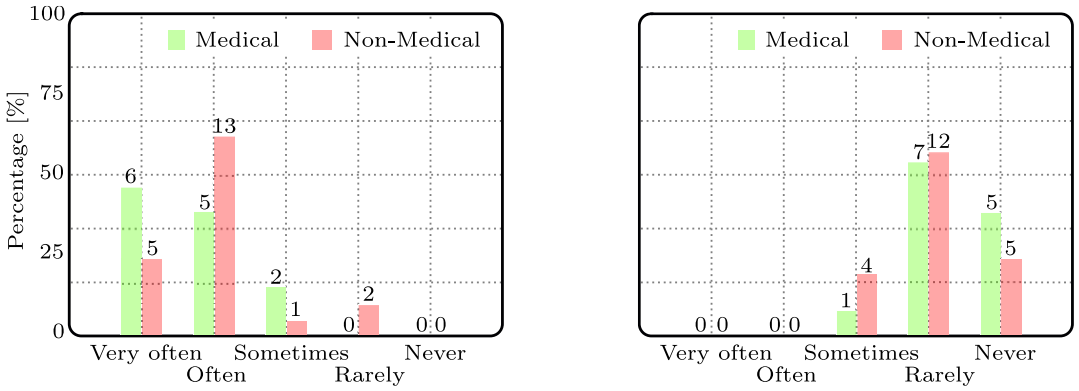
(a) Statement 9 (b) Statement 10

Figure 5. Statement 9: 'I am pleased with how I am able to keep up with helping techniques and protocols we develop'. Statement 10: 'I am the person I always wanted to be'.



(a) Statement 11 (b) Statement 12

Figure 6. Statement 11: 'My work makes me feel satisfied'. Statement 12: 'I feel worn out because of my work as a helper'.

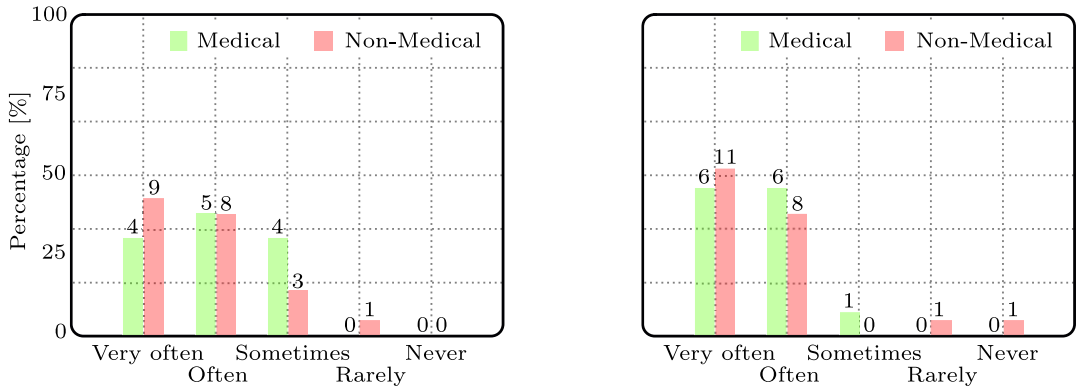


(a) Statement 13 (b) Statement 14

Figure 7. Statement 13: 'I have happy thoughts and feelings about those I help and how I could help them'. Statement 14: 'I feel overwhelmed because my project workload seems endless'.

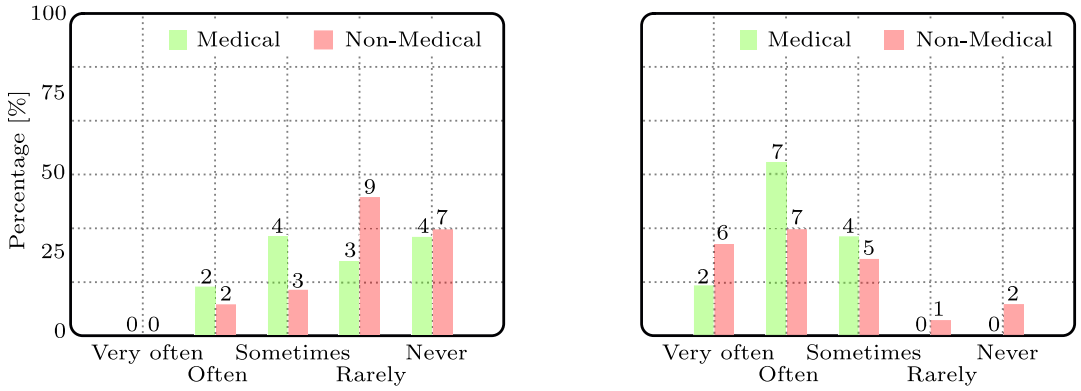
When asked to rate how they like their work as a helper, both the groups answered similarly (Fig. 4(a)). The statement 'I have beliefs that sustain me' produced different responses between the two groups (Fig. 4(b)). In the

medical group, 61.5% replied ‘very often’, as opposed to only 38% in the non-medical group.



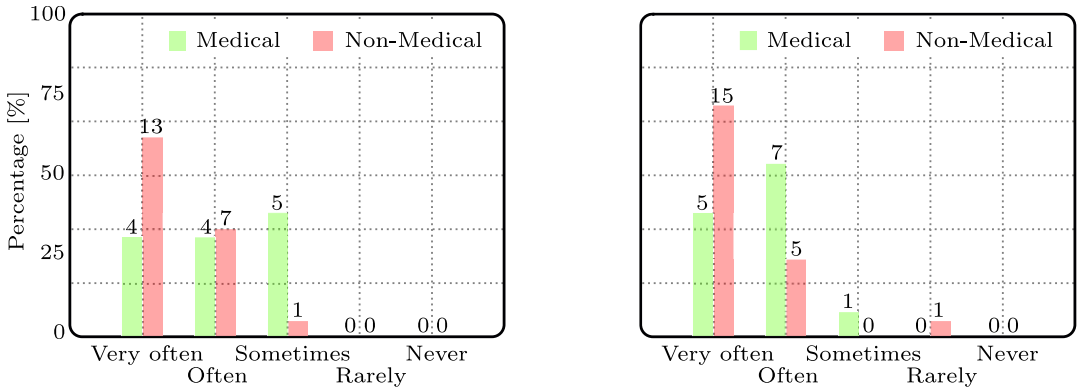
(a) Statement 15 (b) Statement 16

Figure 8. Statement 15: ‘I believe I can make a difference through my project’. Statement 16: ‘I am proud of what I can do to help’.



(a) Statement 17 (b) Statement 18

Figure 9. Statement 17: ‘I feel “bogged down” by the system’. Statement 18: ‘I have thoughts that I am a “success” as a helper’.



(a) Statement 19 (b) Statement 20

Figure 10. Statement 19: ‘I am a very caring person’. Statement 20: ‘I am happy that I chose to do this project’.

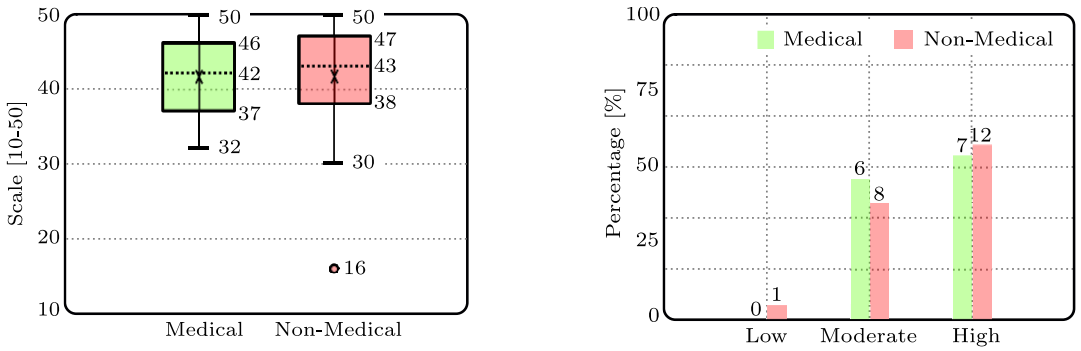
Of the medical students, 54% said they were ‘very often’ or ‘often’ pleased with how they were able to keep up

with helping techniques and protocols they developed. The same was felt by 76% of the non-medical students (Fig. 5(a)). In Fig. 5(b), the responses to 'I am the person I always wanted to be' are shown. They do not vary significantly across the two groups, i.e., medical, and non-medical students. In both groups, ~62% of them confirmed that they either 'very often' or 'often' feel like they were the person they always wanted to be.

Both the groups, medical and non-medical, were asked to rate how often their work makes them feel satisfied, and 77% and 90%, respectively, replied 'very often' or 'often', see Fig. 6(a). While 100% of medical students never or rarely felt worn out because of their work as helpers, 86% of non-medical students felt the same (Fig. 6(b)). Same portion of students from both the groups experienced happy thoughts and feelings about those they could help and how they could help them (Fig. 7(a)). Of the medical students, 62% sometimes or rarely felt overwhelmed because of the workload form their projects, compared to 76% of the non-medical students who felt the same (Fig. 7(b)).

Higher portion of non-medical students stated that they believed they could make a difference through their projects, i.e., 81% as opposed to 69% of medical students; see Fig. 8(a). Around the same portion of both the groups answered that they are (very often or often) proud of what they can do to help (Fig. 8(b)). Of the medical students, 46% felt "bogged down" by the system, whereas only 24% of the non-medical students felt that way (Fig. 9(a)). Similar portion of both the groups had thoughts that they were "success" as a helper, 69% and 62% of the medical and non-medical students, respectively; see Fig. 9(b).

Interestingly, only 31% of medical students self-described as being a very caring person 'very often' as opposed to 62% of non-medical students (Fig. 10(a)). Being a very caring person either 'very often' or 'often' was chosen by 62% and 95% of medical and non-medical students, respectively. Similarly, 38% and 71% of medical and non-medical students, respectively, expressed being `very often' happy that they chose to do this project. However, almost all students from both groups stated being either `very often' or `often' happy that they chose to do this project (Fig. 10(b)).



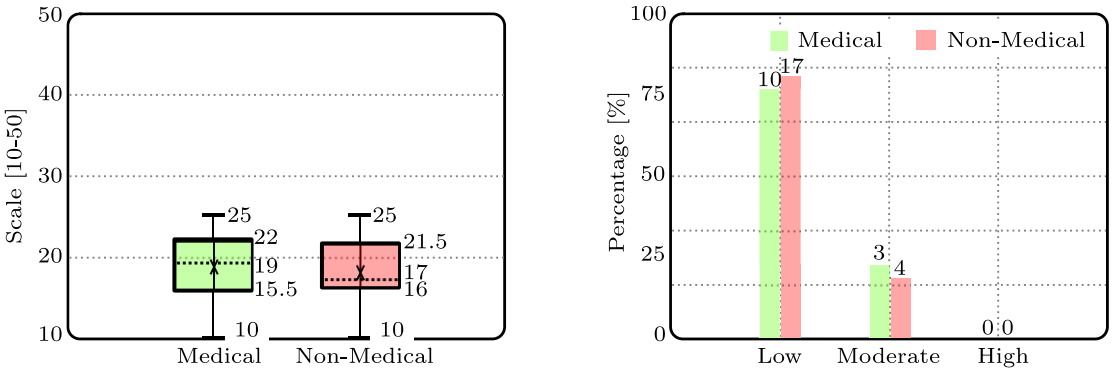
(a) Box Plots (b) Levels

Figure 11. Compassion Satisfaction

The *compassion satisfaction* score for each student is calculated as instructed in ProQOL using the statements 2, 4, 7, 9, 11, 13, 15, 16, 18, and 20. Each item is rated ranging from 'never' = 1 to 'very often' = 5. The resulting

scores are sums of those ratings, thus ranging from 10 to 50. The box plots for both the groups, i.e., medical and non-medical, are shown in Fig. 11(a), with the minimum, lower quartile, median, upper quartile, and maximum values included. The interquartile ranges, i.e., the squares from lower to upper quartiles, showing the middle 50% of scores, for both the groups (medical and non-medical), are similar. Moreover, the median values of both groups are, too, similar, i.e., 42 & 43. Those similarities reveal that there is a minimal difference in the *compassion satisfaction* scale between the two groups. The scores are classified as low (≤ 22), moderate (23 – 41), and high (≥ 42). Fig. 11(b) shows a graph depicting the percentage of students in each classification/level, i.e., low, moderate, and high. That graph, too, demonstrates similarity between the two groups.

Similarly, *burnout* score for each student is calculated as instructed in ProQOL using the statements 1, 3, 5, 6, 8, 10, 12, 14, 17, and 19. On the *burnout* scale, the statements 1, 3, 8, 10, and 19 are reverse scored. Scientifically, the measure works better when those statements are asked in a positive way. Of the medical students, 77% falls under the low *burnout* level, which means they have positive feelings about their ability to be effective in their work. The same can be said about 81% of non-medical students. Hence, similarities can be observed in the graphs in Fig. 12, suggesting that there is a minimal difference in the *burnout* scale between the medical and non-medical students.



(a) Box Plots (b) Levels

Figure 12. Burnout

Statistical Analysis

Welch's t-test is used to analyze the data statistically (Gaetano, 2019). It is selected because it corrects for measurement bias caused by the two groups having different sample sizes and sample variances. Each answer to a statement is assigned a value as explained above, i.e., rated on a five-point scale ranging from "never" (1) to "very often" (5). For *compassion* and *burnout*, values are assigned to the levels, ranging from "low" (1) to "high" (3). The test outcomes are $t(df)$ and p, where the t is t-statistic value, the df stands for degrees of freedom, and the p is p-value. If the p-value is inferior or equal to the significance level, it can be concluded that the mean values of the two groups are significantly different.

Additionally, a range of effect sizes is included in Tab. 1, where all the results can be found. The effect sizes are Cohen's d, Cohen's U_3, percentage of overlap (OVL), and probability of superiority (AUC). The interpretation of

Cohen's d is not straightforward, but researchers often use general guidelines, such as small (0.2), medium (0.5) and large (0.8) when interpreting an effect. The other effect sizes are interpreted as follows. For example, for statement 1, with a Cohen's d of 0.1666, 56.6171% of the medical group are above the mean of the non-medical group (Cohen's U_3), 93.36% of the two groups overlap, and there is a 54.6898% chance that a person picked at random from the medical group will have a higher score than a person picked at random from the non-medical group (probability of superiority).

Table 1. Welch's t-test for Comparing the Responses from Medical and Non-medical Students

Statement	Mean med	StDev med	Mean non-med	StDev non-med	*t*	*df*	*p*	Cohen's d	Cohen's U_3 (%)	OVL (%)	AUC (%)	SIGN
1	4.0769	0.6405	3.9524	0.8047	0.4986	29.8242	0.6218	0.1666	56.6171	93.3600	54.6898	NO
2	4.6154	0.5064	4.5714	0.7464	0.2044	31.6430	0.8394	0.0659	52.6287	97.3699	51.8595	NO
3	4.1538	0.8006	4.1429	0.8536	0.0379	26.8512	0.9700	0.0132	50.5256	99.4744	50.3716	NO
4	4.3077	0.6304	4.3810	0.9735	-0.2663	31.8866	0.7918	0.0851	53.3904	96.6065	52.3989	NO
5	1.6154	0.7679	1.2857	0.4629	1.3985	17.4751	0.1799	0.5532	70.9951	78.2071	65.2176	NO
6	1.8462	0.9871	1.4286	0.8106	1.2811	21.8289	0.2141	0.4740	68.2252	81.2655	63.1253	NO
7	4.0000	0.9129	3.9524	1.0713	0.1382	28.6767	0.8911	0.0469	51.8714	98.1281	51.3235	NO
8	4.6154	0.5064	4.1429	1.0142	1.8028	30.9785	0.0815	0.5497	70.8727	78.3443	65.1242	NO
9	3.8462	1.0682	3.9524	1.2440	-0.2644	28.5393	0.7934	0.0899	53.5830	96.4133	52.5353	NO
10	3.8462	0.8006	3.6667	1.0165	0.5718	29.9842	0.5718	0.1907	57.5605	92.4052	55.3622	NO
11	4.0000	0.7071	4.1429	0.7270	-0.5663	26.1308	0.5760	0.1985	57.8680	92.0933	55.5817	NO
12	1.6154	0.5064	1.7619	0.8310	-0.6388	32.0000	0.5276	0.2017	57.9924	91.9670	55.6706	NO
13	4.3077	0.7511	4.0000	0.8367	1.1108	27.7074	0.2764	0.3819	64.8743	84.8554	60.6444	NO
14	1.6923	0.6304	1.9524	0.6690	-1.1417	26.7611	0.2640	0.3972	65.4376	84.2590	61.0582	NO
15	4.0000	0.8165	4.1905	0.8729	-0.6437	26.9057	0.5254	0.2235	58.8434	91.1014	56.2792	NO
16	4.3846	0.6504	4.2857	1.0556	0.3380	31.9964	0.7376	0.1070	54.2587	95.7352	53.0142	NO
17	2.3077	1.1094	2.0000	0.9487	0.8297	22.5507	0.4156	0.3041	61.9459	87.9163	58.5117	NO
18	3.8462	0.6887	3.6667	1.2383	0.5424	31.7634	0.5914	0.1684	56.6860	93.2904	54.7388	NO
19	3.9231	0.8623	4.5714	0.5976	-2.3801	19.1793	0.0279	0.9150	81.9911	64.7303	74.1190	YES
20	4.3077	0.6304	4.6190	0.7400	-1.3082	28.6815	0.2015	0.4442	67.1553	82.4234	62.3277	NO
Compassion	2.5385	0.5189	2.5238	0.6016	0.0752	28.4574	0.9406	0.0256	51.0218	98.9781	50.7226	NO
Burnout	1.2308	0.4385	1.1905	0.4024	0.2686	23.8765	0.7906	0.0968	53.8553	96.1402	52.7282	NO

Criterion of significance is set to five percent, i.e., 0.05 significance level. Of the 20 statements only one statement produced answers statistically different between the two groups at the 0.05 significance level, see the row in Tab. 1 highlighted in gray. In that row, i.e., statement 19, the *p* value is less than 0.05. The Cohen's d for that statement is also high (0.915), i.e., large effect. While other statements did not collect answers statistically different between the two groups (i.e., p-values > 0.05), the Cohen's d in some other statements can also be found higher, ≈0.5 (i.e., medium effect).

Discussion

Undergraduate medical education has evolved necessarily with the increasing utilization of technology and the availability of ancillary resources developed for medical students. A post-exam survey devised to evaluate medical students for resource usage, student-perceived preparedness, and exam performance, found that none of the purchased resources utilized improved student exam performance (Bauzon et al, 2021). More importantly, through the examination of overarching themes and roles of emotions and emotionality within medicine, it is shown how the rise of an emotion-deficient empathy is reflective of a persistent focus on clinical knowledge, detachment, and

the rationality of science (Michalec, 2012; Shapiro, 2011; Underman & Hirshfield, 2016). An overview of the literature where the authors tried to assess 'what is a good doctor' can be found in (Steiner-Hofbauer, Schrank, & Holzinger, 2018). Patients and doctors have different ideas about the concept of a good doctor. Patients put more emphasis on communication skills, whereas doctors value medical skills more. Misalignment between patients and doctors due to improper communication results in degraded quality of healthcare (Singh & Key, 2021).

Based on the self-ascribed field of expertise, the participants in this study were with very diverse backgrounds and yet they decided to work and communicate together to study problems and develop solutions. Medicine is a profession that emphasizes service to others. Hence, the medical students are accustomed to helping others. The STEM students do not encounter the possibility to use their work to help others on such a regular basis. Hence, they appeared to have been more excited when asked how they felt about this project giving them the opportunity to service others. However, comparatively, significantly larger portion of the non-medical students never felt connected with the traumatic experiences of the people they get to help with their work. Similarly, relatively higher portion of non-medical students never felt trapped by their project as a helper. Those responses can be explained by the fact that, compared to the medical students, smaller portion of the non-medical students felt sustained by the beliefs they held.

'Very often' or 'often' higher portion of the non-medical students felt pleased with how they were able to keep up with the techniques and protocols they developed, compared to the medical students. It is understandable that once their projects progressed into the development stage the medical students might have felt a little lost in the procedures undertaken by the non-medical students. The misalignment between patients and doctors due to improper communication from doctors to patients was discussed above. However, in this study an improper communication from non-medical to medical students was identified as evidenced by the smaller number of medical students feeling pleased with their ability to keep up with the techniques and protocols when working on engineering-based projects with non-medical students.

Compared to medical students, higher portion of non-medical students replied that their work makes them feel satisfied. That too is understandable, considering that the non-medical students do not as often encounter the possibility to be in the role of a helper as compared to the medical students for whom being in that role is more common. Similarly, while all medical students never or rarely felt worn out because of their work as helpers, some of the non-medical students felt worn out.

Conclusion

Medical students are accustomed to conducting a lot of extracurricular activities even, or especially, prior to being accepted to a medical college. Understandably, smaller portion of the medical students felt overwhelmed (sometimes or rarely) by the workload from their projects than the non-medical students. Proportionally, the non-medical students identify themselves as very caring twice as often as the medical students.

The *compassion satisfaction* and *burnout* scales show little to no difference between the medical and non-medical

students. On the *compassion satisfaction* scale, 54% and 57% of the medical and non-medical students, respectively, classify at the high level, meaning they probably derive a good deal of professional satisfaction from their work. The others may either find problems with their work, or there may be some other reason, such as they might derive their satisfaction from activities other than their work. On the *burnout* scale, most of the students from both groups classify at the low level (77% and 81%, respectively), meaning they probably have positive feelings about their ability to be effective in their work. The rest (23% and 19%, respectively) classify at the moderate level. However, that score may reflect the student's mood; perhaps they were having a "bad day" or needed some time off. If the high score persists or if it is reflective of other worries, it may be a cause for concern.

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Author Information

Milan Toma
https://orcid.org/0000-0003-2154-3728
New York Institute of Technology
College of Osteopathic Medicine
Northern Boulevard, P.O. Box 8000, Old Westbury, 11568, New York, USA
Contact e-mail: *tomamil@tomamil.com*

Faiz Syed
https://orcid.org/0000-0001-9294-2537
New York Institute of Technology
College of Osteopathic Medicine
Northern Boulevard, P.O. Box 8000, Old Westbury, 11568, New York, USA

Lise McCoy
https://orcid.org/0000-0003-4788-861X
New York Institute of Technology
College of Osteopathic Medicine
Northern Boulevard, P.O. Box 8000, Old Westbury, 11568, New York, USA

Michael Nizich
https://orcid.org/0000-0002-3922-5659
New York Institute of Technology
College of Engineering and Computing Sciences
Northern Boulevard, P.O. Box 8000, Old Westbury, 11568, New York, USA

William Blazey
https://orcid.org/0000-0003-1470-188X
New York Institute of Technology
College of Osteopathic Medicine
Northern Boulevard, P.O. Box 8000, Old Westbury, 11568, New York, USA