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# The Prominent Roles of Undergraduate Mentors in an Online Near-Peer Mentoring Model

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**Abstract:** This study exemplifies a STEM-based online near-peer mentoring approach, incorporating 56 students (high and middle school mentees) and 16 secondary undergraduates (UG) mentors. The various constructive roles of UG mentors in motivating student mentees have been investigated by examining the mentoring relationship shared among them. The qualitative and quantitative analysis of the student's daily feedback, mentors' feedback, and UG mentors-mentees transcripts has illustrated that consistent asynchronous appreciation, encouragement, and support (academic technical) was responsible for the success of the model. The finding also demonstrated a decline in the amount of motivation requirement of the mentees in the successive weeks of the courses, indicating the attainment of self-sufficiency. Furthermore, comparative analysis revealed a greater amount of motivation requirement and enhanced bonding between the middle school mentees and UG mentors, compared with high school mentees and UG mentors. Therefore, unlike many studies depicting the model's success, our article is an aid in understanding the underlying process, contributing to the success. Thus, this educational approach is an aid in motivating and augmenting students' engagement during online STEM education, which is crucial for cultivating and retaining STEM interests among the young generation of the nation.

**Keywords:** undergraduate mentor; near-peer mentoring; student motivation; online learning; STEM

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## 1. Introduction

The online mode of learning has gained immense importance during the outbreak of COVID-19. Though the online learning concept has been a savior during the current pandemic, its implementation was/has been quite challenging [1]. The eight major challenges associated with online education are the lack of learner motivation; reduced social interaction; insufficient time and support for the studies; lack of technical skills; the dearth of academic skills; administrative issues; expense and reliable access to the internet; and the technical glitches [2]. Most of the challenges of online education are interlinked with the course structure/design and the way it is delivered and perceived [3].

Clark et al. showed that no substantial differences should be expected regarding the success of well-designed online learning compared with well-designed in-person learning [4]. Regardless of this, significant differences still exist. One prominent reason for this difference is the way students perceive their online experiences during learning. This could in turn be related to student motivation [5].

Thereby, the paper encompasses an educational approach to alleviate this concern of "lack of student motivation". With a special focus on the "virtual hands-on STEM (Science, Technology, Mathematics and, engineering) classroom", we have designed and implemented a STEM-based course for middle school and high school students. Wherein, these school students are consistently motivated and guided by the UG mentors (Undergraduate mentors), i.e., via a near-peer mentoring approach. This tactic is crucial for driving the students to creativity and STEM innovations. A triangulation assessment approach has been employed to ensure active student engagement and motivation. In this assessment approach, the students are assessed via direct, indirect, and embedded means. In the direct assessment, students are assessed through observable tasks done by the students such as project presentations, assignments, etc. by the STEM experts. In the indirect assessment, students are assessed by indirect means such as feedback from students, and by the UG mentors. While in the embedded assessment, students are assessed by on-sessions tasks and assignments, that are crucial for proceeding to the subsequent topics of the session. The table below (Table 1) briefs the peculiarity of our approach and the eminence of UG mentors.

**Table 1.** Features of the online undergraduate (UG) near-peer mentoring model for STEM education.

| The Peculiarity of the E-STEM Program, Incorporating the UG Near-Peer Mentoring Approach |
|---|
| 1. The UG students worked as secondary mentors to the school students. |
| 2. Continuous asynchronous guidance to the school students by the UG mentors. |
| 3. Consistent student motivation by the UG mentors via text messages. |
| 4. Collaboration, emotional attachment, and rapport of the UG mentors with the students. |
| 5. Indirect and embedded assessment of the school students by the UG mentors |
| 6. The course aided 3 types of interactions for the students—i.e., UG mentor—student, student-student, student-STEM experts. |
| 7. The course bridged the schools with the university through UG- near-peer mentorship. |
| 8. The course supported outcomes-based teaching by employing synchronous and asynchronous activities such as real-time interactive online sessions, consistent online meetings (off-session), WhatsApp chats/calls, real-time educational games, poster making, seminars, exploring learning videos, hands-on scientific experiments, and group discussions. |

Thereby, the paper unambiguously briefs and concludes the constructive role of the UG mentors in motivating the school students towards their active participation and STEM innovations, during online learning. Finally, the paper compares the effect of the online near-peer mentoring approach on middle school and high school students.

## 2. Review of Literature

### *2.1. Near-Peer Mentoring*

Traditional mentoring involves a hierarchical relationship between a younger mentee and an elder experienced mentor. However, a mentor can also be a peer or a near-peer who is closely related in age or position, in a near-peer mentorship model. Mentoring is extremely essential for individuals' development/gains in terms of cognitive, affective, and behavioral. Particularly, in the field of STEM-based mentoring models, many studies have already reported these gains [6–8]. Mentoring in the field of science also promotes the development of early-career scientists [9]. Thus, when compared to the traditional model with the senior (supervisory) mentors, "peer or near-peer mentors" prove to be more effective because of the relatable experiences, emotional support, and shared personnel connections [10]. The near-peer mentorship model was first founded at the Walter Reed Army Institute of Research [11]. Wherein a near-peer mentor was an UG or post-baccalaureate student, who mentors middle and high school students, as a part of their summer internship program [11]. It is also noteworthy to know the clear distinction between a classical UG mentoring model and an UG near-peer mentoring model. The former typically involves an UG (mentee) and an expert (mentor) [12], where the UG mentee is limited to teaching experience [13]. Whereas, the latter allows the UG mentor to teach, by acquiring and sharing knowledge with the younger mentees, under the supervision of an expert. During the near-peer mentoring model, social and cognitive relatedness is considered to be the key determinant of the mentoring relationship [14,15].

### 2.2. Mentoring Relationships: Social and Cognitive Compatibility

A study by Goldner L., and Mayseless O., (2009), demonstrated the link between the quality of the relationship and mentees' academic and social improvements [16]. Dubois and Neville (1997) also revealed that near-peer mentoring results in increased benefits for teenagers [17]. More specifically, Rhodes et al. (2006) reported that high-quality mentoring relationships mean mentor-mentee closeness, legitimacy, empathy, and empowerment [18]. In addition, this high-quality mentoring relationship is dependent on the frequency of contact between the mentor-mentee, their emotional bonding, and the durability of their relationship [19]. In the educational context, near-peer mentoring relationships mean that the mentors are able to support mentees' academic and psychosocial needs [20]. For this, mentors and mentees should share cognitive and social compatibilities/similarities [15].

Social similarities refer to perceived social compatibilities such as the shared educational experiences between the mentor and mentee. Such a resemblance will aid in the development of compassion, faith, conviction, and self-disclosure [21]. Ten Cate and Durning (2007) relate social congruence with the affective and motivational level of learning [15]. They also conclude that near-peer mentors are better than the academic staff in terms of understanding students' motivations. Social congruence is strong when mentors share their own prior or present learning experiences and challenges [19]. In turn, such a relationship aids in mentees' feeling that they are being understood by mentors [22]. Thus, allowing for more self-discloser of the learning gaps, and enabling subsequent support from mentors. Contrary to social congruence, cognitive similarity means mentors' ability to realize mentees' cognitive aspects (learning and challenges) [23]. An emergent property of cognitive compatibility occurs when mentors can identify mentees' learning gaps and employ scaffolding and language suitable to mentees' current cognitive development [24].

A successful mentoring relationship is based on both social and cognitive capabilities [14], however, social compatibility is typically formed earlier than cognitive compatibility. A dynamic and emotional connection must be established prior to conveying the learning objectives to the students [25]. Therefore, social compatibility needs to be developed before mentors can make use of their cognitive compatibilities to provide academic and motivational support. Establishing such a relatedness (social and academic congruence) in an online setup has to be explored deeply for developing the online near-peer mentoring model for STEM education.

### 2.3. Online Mentoring Programs

Online mentoring can be in a synchronous or asynchronous setting. Interactions via text-based media relate to asynchronous settings. Whereas the video and audio-conferencing tools relate to synchronous settings [26]. Online mentoring programs present many advantages to participants, compared to face-to-face programs. Scogin S. C. (2016) claim that online mentoring balances the participant's interactions and are negligibly affected by demographic differences [26]. Furthermore, online participants have a greater chance of developing self-efficacy and positive relationship experiences, compared to the classroom setting [27,28].

Despite the increasing advantages and importance of online mentoring, there are a few studies that report the near-peer mentoring dynamics. In the context of the challenges associated with asynchronous and synchronous; there are mixed results in the literature. A study by Scogin S. C. (2016) found that mentors provided motivational support for better mentees' engagement in science via text-based communications only [26]. Although the asynchronous tools are convenient to use [29]; the lack of real-time interaction, can contribute to decreased engagement, if the mentor-mentees do not keep communicating timely [27]. On the other hand, synchronous communication tools—such as web-conferencing- are primarily aimed to address the shortcomings of asynchronous tools. Thus, these tools can augment participants' sense of relatedness by reducing the psychological distance [26]. On the other hand, a study by Beaumont et al. (2012) showed that the mentees' sense of relatedness with mentors was also low during a synchronous online mentoring program [29]. Hizer et al. (2017) investigated the impact of employing synchronous and asynchronous communication tools and reported that mentees preferred asynchronous chat-based interactions over synchronous sessions [30]. In a similar context, this study also presents the effectiveness of a near-peer mentoring model, based on asynchronous text-based motivation provided to the mentees. The importance of the student motivation model could be well explained by the self-determination theory (SDT), proposed by Deci and Ryan (1985) [31].

### *2.4. Theoretical Framework*

The SDT supports the theoretical background of the study. The theory suggests that all individuals possess three psychological needs—autonomy (i.e., feeling of being self-governed and self-endorsed), competence (feeling of being competent and effective), and relatedness (feeling of being connected, loved, and interacted)—this ultimately arouses them to act/not to act. When the teaching design addresses these psychological needs, students are actively motivated to engage in learning tasks [32]. Motivation should be considered an important aspect because motivated students perform better and experience more positive attitudes, contributing to a deeper learning outcome [33,34]. Furthermore, Knowles et al., (2007) have shown that student motivation is highly governed by student-student, student-teacher, and student-material interactions [35]. Interestingly, according to Ensher et al., (2013), motivational mentoring via asynchronous online mode promotes greater engagement than traditional classroom setting [27]. On contrary, Chiu 2021 argues that although SDT has been widely focused on and employed in the face-to-face context [36], it has been widely ignored in an online learning setup [36]. Even though measuring and assessing motivation in an online context is challenging, SDT [32] is a valuable theoretical framework for explaining strong relationships between the mentors-mentees in terms of student motivation.

## **3. Research Questions**

The online near-peer mentorship approach for STEM education could be highly beneficial to alleviate, one of the most common concerns of an online course i.e., "Student Motivation". Although previous research shows the success of online near-peer mentoring models [14,27], the processes that reinforce positive outcomes for the participants remain highly unexplored. Therefore, to fill the literature gap, our study aids in understanding the underlying process contributing to the success of this model. We have followed recommendations from previous studies (Leidenfrost et al. (2011) and Zaniewski and Reinholz (2016)) to understand and monitor the mentoring relationships and evaluate the various roles of mentors [36,37]. This study has explored how mentors have developed online mentoring relationships and what approaches have been employed to engage mentees. Therefore, the paper is an aid in exploring the exceptionally resilient relationship between the UG mentor and the students' mentee. Wherein, the UG mentors have gone beyond their limits to motivate and support the mentees to successfully undergo their E-STEM course. In addition, a comparative analysis of the models, when implemented for middle school and high school students has also been investigated. Thus, the following research questions have been addressed:

RQ 1: How was the online mentoring relationship established between the UG mentors and students?

RQ 2: What was the comparison of middle and high school students' relationship with the UG mentors?

## 4. Materials and Methods

### *4.1. Online STEM Program Structure and Course Design*

To limit the learning losses and keep the curiosity intact among the students during the COVID crisis, an online STEM-based summer program was launched at the national university of Qatar. There were eight program facilitators (research assistants, research specialists) who specialized in STEM-based workshops' design, delivery, and development. The courses were designed for middle and high school students and were exercised for 3 weeks. The topics for the STEM courses were "Force" for middle school students and "COVID-19 and its impacts" for high school students [38]. The course sessions were 1 h per day with hands-on experiences. Every session was broken down into 3 parts (1) introductory; (2) scientific, and (3) concluding part. Research-based sessions were designed to allow students to actively participate and engage; gain hands-on experience and learn new techniques; explore novel thoughts, and make new links between STEM and their learning/interests for wonderful innovations [39]. Eventually, the students were required to submit their novel innovations in the form of an idea or product in the finale.

### *4.2. Participants of the Study*

Interested students registered in the online STEM-based summer program. In addition, the total number of participants was 56 school students, involving middle and high school students (Table 2). The middle school students were from grades IV–VI and high school from grade XI–XII.

**Table 2.** General demographics for the participants of the study.

| | Academic Level | Male Participants | Male Groups | Female Participants | Female Groups | Total Participants |
|---|---|---|---|---|---|---|
| **Mentee** | High school | 6 | 3 | 12 | 4 | 18 |
| **Mentee** | Middle school | 14 | 7 | 24 | 8 | 38 |
| **Secondary Mentor** | UG students | 5 | - | 11 | - | 16 |

16 UG students participated in the program, and their enrollment was based on their willingness to join such a program and take in the responsibility of mentoring the school students. The UG mentors were with the program, as a part of their summer project. The participating students ($n$ = 56) were divided into small groups (Table 2) for aiding a student-centered approach. There were 15 and 7 groups of middle school students ($n$ = 38) and high school students ($n$ = 18), respectively. There were separate groups for male and female students. Each group was mentored by one UG mentor. The ratio of UG mentors with the male and female student groups was in ratio 1:2 and 1:3, respectively. This proportion was set, based on the prior literature supporting the fact that male participants require more support and guidance than females [40,41]. Therefore, each group consisted of students (two boys or three girls), a UG mentor, and a STEM expert (refer to Figure 1). The reason behind opting for this small sample size of 56 students and 16 UG mentors was to closely comprehend the students' learning gains, learning behaviors, and the mentoring relationship shared among them. It is also noteworthy that it was the first batch of students who acclimated to the online course during the COVID-mediated lockdown. Therefore, we ensured that every student groups were properly and consistently guided, mentored, and motivated throughout the online STEM course.

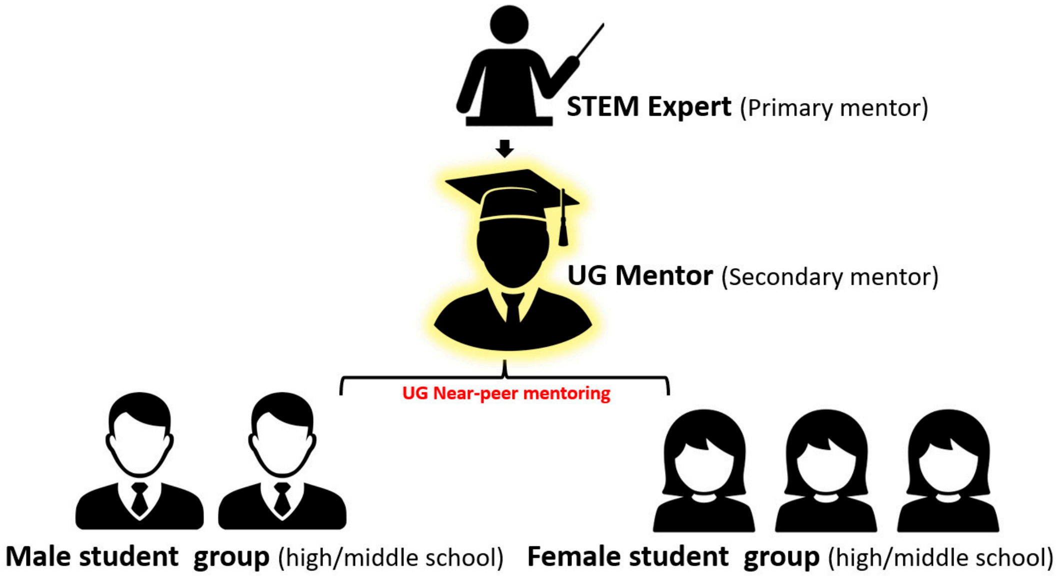


**Figure 1.** Hierarchy of the mentoring model, revealing UG near-peer mentoring (UG mentor-student mentee).

### *4.3. Programs' Educational Tools*

To promote a unique learning experience, content delivery was effectively structured with various educational tools to execute the program efficiently. The primary online platform employed for content delivery was MS TEAMS by the primary mentors (STEM experts). Various synchronous and asynchronous tools (PowerPoint presentations, videos, puzzles, Kahoot, audio calls, WhatsApp messaging, MS office, PowToon, etc.) were employed. Consistent motivation and support provided by the UG mentors (secondary mentors) through asynchronous text messages were the key predictors of student engagement and retention throughout the course.

### *4.4. Data Collection and Analysis*

Several online communication platforms were used to successfully execute the E-STEM courses such as WhatsApp groups, MS TEAMS chat rooms, and private channels. The data from text message transcripts, students' daily feedback forms, and mentors' feedback forms were analyzed. The questions in the students' daily feedback forms were (1) what did you like the most? (2) what did you like the least? (3) any suggestions (refer to Table A1). UG mentor-student mentee's text message transcripts and feedback were qualitatively investigated to understand the role of UG mentors. The data analysis was primarily using 28 text message transcripts, involving 56 students and 16 UG mentors. The text message transcripts of 4 middle school student groups couldn't be retrieved, thus only 11 groups were considered in the study. The original version of the transcripts was in Arabic. The collected text message transcripts were segregated based on the school level (high school or middle school) and the gender of the participating students. The messages/keywords in the transcript were judiciously examined and color-coded. The colors used for highlighting the keywords and messages were specific and were related to the various roles of the UG mentors. The color highlighters used, were for the following criteria: UG mentors encouraging the students, UG mentors appreciating the students, and UG mentors supporting the students (technically and academically) (refer to Table 3). Keeping in view of the informal nature of the transcripts, the texts not abiding by the criteria in Table 3 (such as random texts, greetings, emoji, etc.) were not included in the study. The color-coded texts were translated (Arabic to English) using Google translate and Microsoft word translate, manually. Finally, the color-coded-highlighted transcript documents were analyzed for the keywords. The keywords abiding by Table 2's criteria were counted every day. Obtained quantitative data were transferred and tabulated in excel sheets. To investigate the trend in the UG mentor-student interactions within the groups, graphs were drawn (Figure 2).

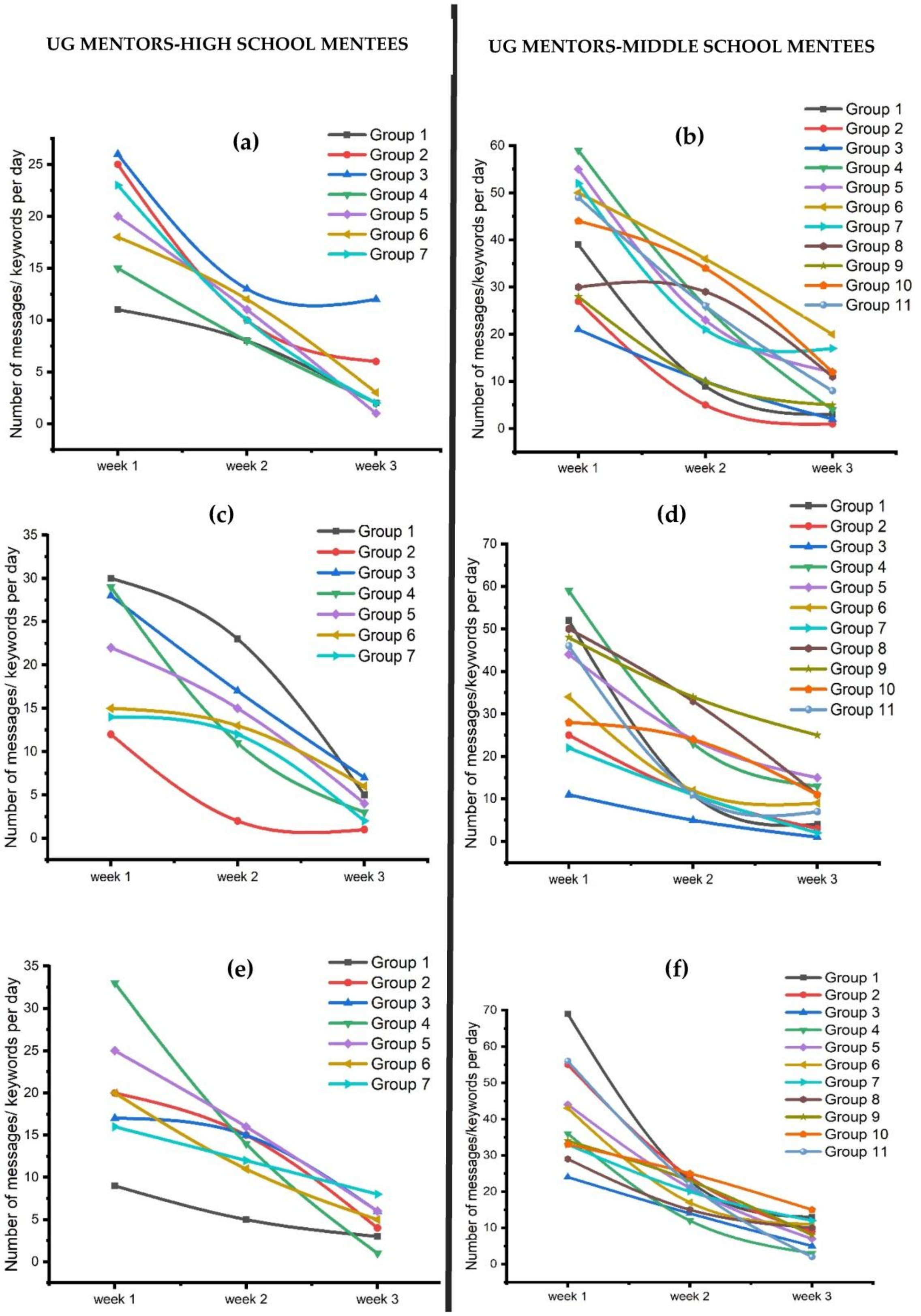


**Figure 2.** *Cont*.

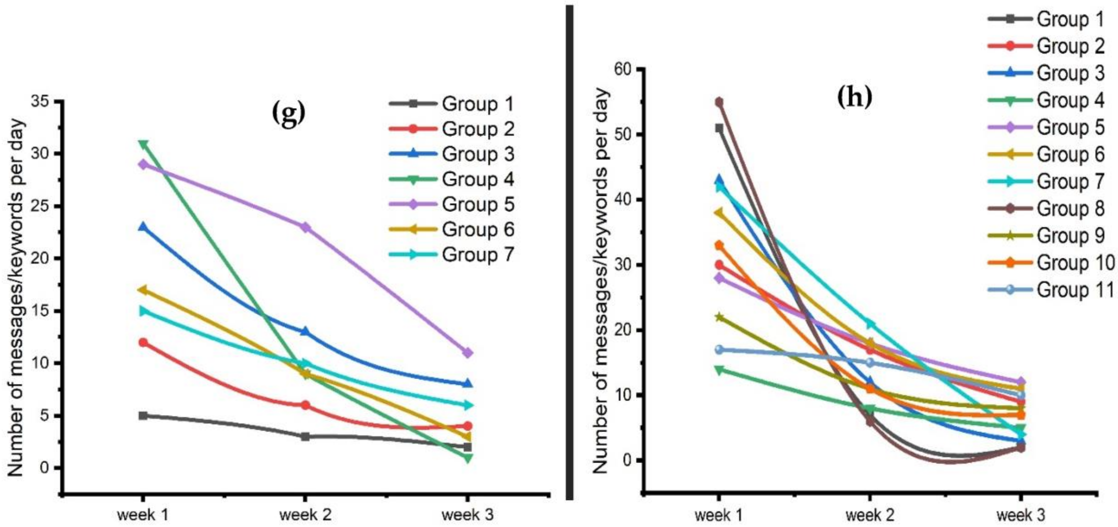


**Figure 2.** Graphs illustrating the level of bonding between UG mentors and school students. (**a**,**b**) Depicts the level of rapport between the UG mentors-high school and UG mentors-middle school students' groups, respectively. (**c**,**d**) Depicts the level of encouragement provided by the UG mentors to high school and middle students groups, respectively. (**e**,**f**) Depicts the level of appreciation provided by the UG mentors to high school and middle students groups, respectively. (**g**,**h**) Depicts the level of support (academic, technical) provided by the UG mentors to high school and middle students groups, respectively.

**Table 3.** The Criteria used for highlighting the text message transcripts.

| | Color-Coded Categories | Example of Keywords/Messages |
|---|---|---|
| **1.** | The rapport between the UG mentors and students | 'I liked this about the session, I didn't like it, I recommend this. We will revise the session." |
| **2.** | UG mentors encouraging the students | "Come on, you can do it, we will win, Are you ready? I know you can, we can" |
| **3.** | UG mentors appreciating the students | "Well done, good job, great, proud of you, I appreciate, keep going, wow, excellent" |
| **4.** | UG mentors supporting the students (Technically and academically) | "Force, COVID-19, video, MS TEAMS, log-in, PPT, YouTube, virus, Newton's law" |

Note: For color coding, the rapport between the UG mentors-student mentees, and the conversation between the UG mentors-students were taken into account. Whereas, for the rest, only the messages from UG mentors were considered.

Similarly, the graph in Figure 3 was also generated with the same text message transcripts. Wherein, the average time spent by the UG mentor with the students has been revealed. The time was calculated whenever there had been a conversation between the UG mentor and the students. The data was tabulated in MS Excel sheets and the graph was plotted (Figure 3). A comparative analysis of mentor–mentee interactions has also been revealed in Figure 4. Thus, the findings of the study justified the prominent roles of UG mentors, along with the comparative analysis.

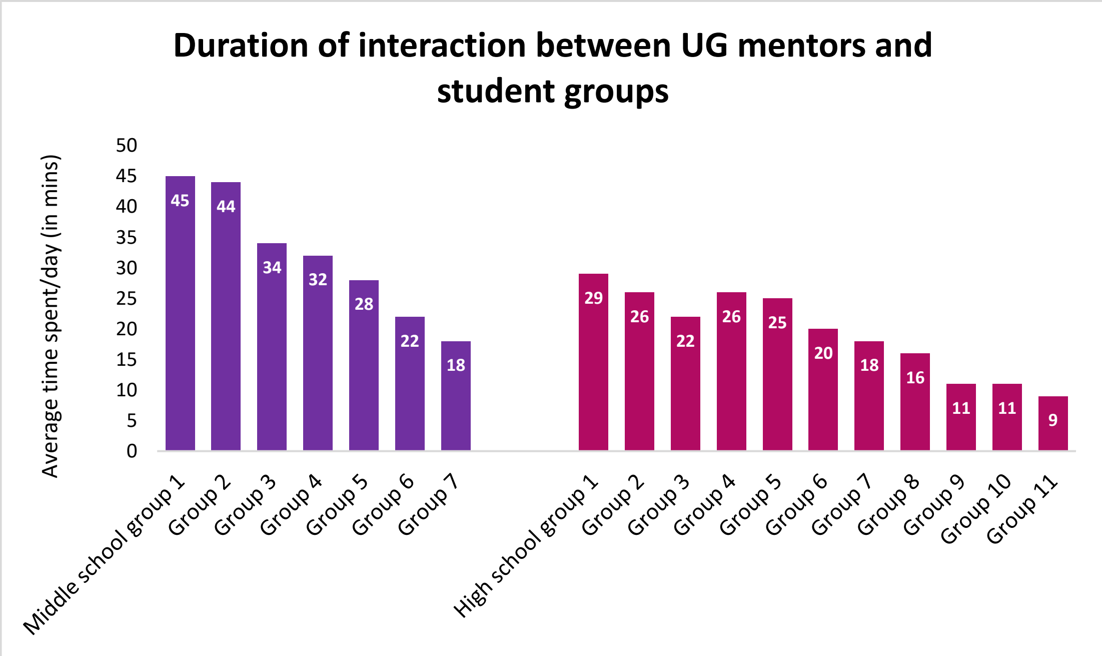


**Figure 3.** Graphical representation of average time spent per day by the UG mentors with the middle and high school students (off- and on-session), respectively.

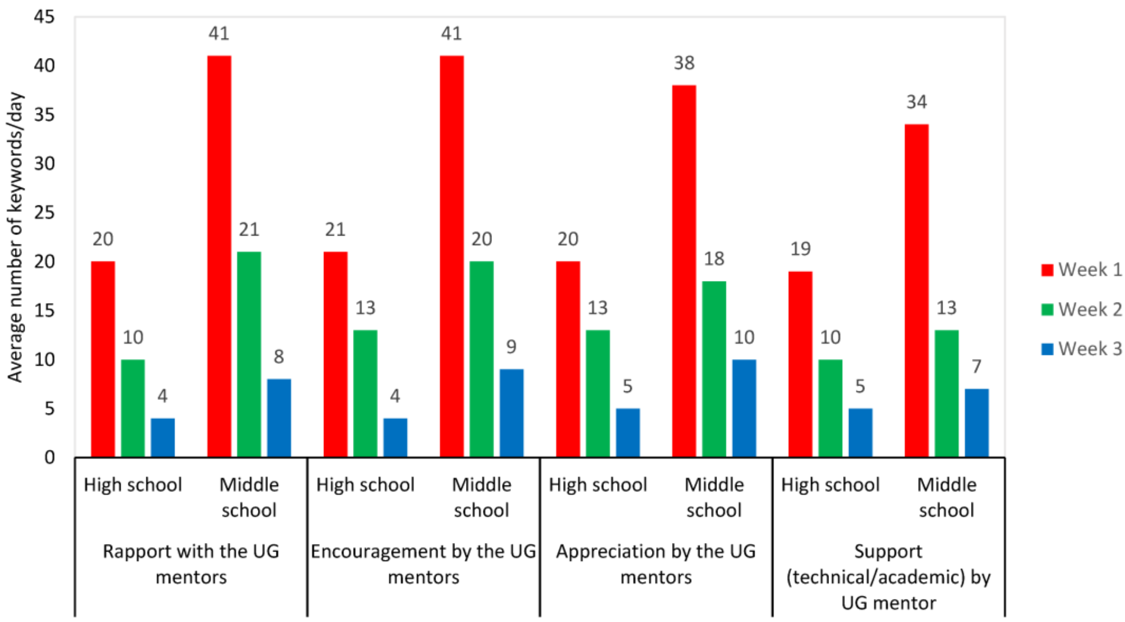


**Figure 4.** A comparative graphical representation of motivation (in terms of rapport, encouragement, appreciation, and support) provided by the UG mentors to the high and middle school students.

## 5. Results and Discussions

To address the first research question of how were the UG mentors asynchronously attached and emotionally bonded with the school students, the evidence from the text transcripts has been investigated. The qualitative text messages were investigated and translated into a quantitative form to make graphs. Figure 2 depicts the level of bonding between the UG mentors and school students. The UG mentors played a prominent role by consistently motivating the participants asynchronously (on-session and off-session). The analysis of transcripts revealed various roles of UG mentors such as appreciation, encouragement, support by creating a rapport, and emotional understanding with the students. A study by Garcia-Melgar, A. and Meyers, N. (2020) has reported these variables as the construct for motivations [14]. All of this eventually helped the students to complete their tasks and be retained in the online STEM course. The retention rate was observed to be 100% of the participating students.

In Figure 2a,b the rapport and bonding between the UG mentor and the student mentees were investigated. It could be noted that the interactions showing the rapport/bonding of the UG mentor-students were very high during the first week of the online STEM program. It reveals the students' enthusiasm, and willingness to engage, and familiarize themselves with the UG mentors, at the start of the course. They were highly motivated to ping the UG mentors, apart from their actual online session to ask doubts, share the session experiences, provide their daily feedback, discuss their assignments, creatively ponder on new projects/products, etc. Subsequently, there has been a decrease in the interactions, in the following weeks. This is due to the fact that STEM training had been given to the students in the initial days and the final days were for the project. Thus, for the project's days, students were more engaged among their teammates rather than with the UG mentors. Another reason for the decline could be due to the students becoming more self-sufficient. This" self-sufficient aspect has been inspected by analyzing the mentors' feedback detailing the task completion by the students. They only required the initial ignition to start and engage with the STEM course. Once that ignition had been provided by the UG mentor, students became more self-regulatory and started doing their assignments and projects on their own, in the following weeks. While investigating the transcripts, some student groups have shown to be highly active with the UG mentors when compared to the others. This disparity cannot be justified by solely relying on results from the transcripts, because they interacted not only via text messages but also via other online platforms (such as emails, MS TEAMS channels, virtual meetings, telephonic conversations, etc.). Moreover, some other possible reasons for decreased/delayed interaction (UG mentor-student) could be due to students using their parents/elder siblings' mobile phones for interaction with the UG mentor. Furthermore, in some student groups, students were more interactive with the primary mentor (STEM experts) than the secondary mentor (near-peer UG mentor).

Although the above-mentioned results show the rapport between the UG mentor-student, further investigations were performed to understand how the UG mentors connected to the students and what was the reason behind this bonding. One possible justification is via their role in motivating the school students. The motivation provided to the students has been further classified into its forms, i.e., if the motivation was in the form of appreciation (in Figure 2c,d), encouragement (in Figure 2e,f), appreciation, or support to the students (in Figure 2g,h),

Thus, on peeping deeper, Figure 2c–f shows that the amount of encouragement and appreciation given by the UG mentors to the middle students was higher when compared to the high school students. This might be probably due to younger students not being well acquainted with the online mode. Another observation was the gradual decline (in the following week) in the amount of appreciation and encouragement provided to the students by the UG mentors. Thereby, these results contribute to the fact that the UG mentors had played a significant role in enlightening/arousing the students, by messaging them more frequently during the initial days. However, with time students had become more independent, and innovative. Similarly, when the amount of support (technical and academic) provided by the UG mentors to the students was investigated, the same has been found, i.e., maximum support was given to the students during the initial days (Figure 2 g,h). Wherein younger students had to be addressed more frequently, clarifying their doubts, giving required scientific information, etc., here also, it gradually decreased in the succeeding days/weeks. In addition, the probable reason for the decline in the interactions could be due to the students becoming more independent. Finally, Table 4 briefs the average scores for the relationship between the UG mentors and middle school mentees (4a) and high school mentees (4b) in 3 weeks of mentoring.

**Table 4.** Average scores for the relationship between the UG mentors and middle school mentees (4a) and high school mentees (4b) in 3 weeks of mentoring.

| **4 (a) Relationship between the UG Mentors and Middle School Mentees** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Week** | **Rapport between the Mentors-Mentees** | | **Encouragement by the Mentor** | | **Appreciation by the Mentor** | | **Support from the Mentor** | |
| | **Mean** | **S.D.** | **Mean** | **S.D.** | **Mean** | **S.D.** | **Mean** | **S.D.** |
| **Week 1** | 41.27 | 12.37 | 41.45 | 12.97 | 38.09 | 14.30 | 33.91 | 12.71 |
| **Week 2** | 20.82 | 10.24 | 19.64 | 4.23 | 18.09 | 9.43 | 13.09 | 4.79 |
| **Week 3** | 8.64 | 6.00 | 8.62 | 3.94 | 9.55 | 5.60 | 6.64 | 3.17 |
| **4 (b) Relationship between the UG Mentors and High School Mentees** | | | | | | | | |
| **Week** | **Rapport between the Mentors-Mentees** | | **Encouragement by the Mentor** | | **Appreciation by the Mentor** | | **Support from the Mentor** | |
| | **Mean** | **S.D.** | **Mean** | **S.D.** | **Mean** | **S.D.** | **Mean** | **S.D.** |
| **Week 1** | 19.71 | 5.06 | 20.00 | 6.97 | 21.42 | 7.16 | 18.86 | 8.65 |
| **Week 2** | 10.29 | 1.75 | 12.57 | 3.49 | 13.28 | 5.92 | 10.42 | 5.90 |
| **Week 3** | 4.00 | 1.25 | 4.71 | 2.11 | 4.00 | 2.00 | 5.00 | 2.21 |

To comprehend the amount of motivation and the extent of support provided to students by the UG mentors with respect to the time has been investigated (in Figure 3). The qualitative records from the transcripts show that the UG mentors were available even at midnight to respond to the students. The average commencing and concluding time of the text messages between the UG mentor and the student was 8 am and 10 pm, respectively. While extreme cases include messages at 4 am and 12 am-midnight. The time spent by the UG mentors with the high school student was comparatively high when compared to the middle school students. This is because elder students tend to be more active via texting. Whereas, younger students are more engaging via video calls/conferencing (in MS TEAMS), phone conversations, etc. rather than texting. Meanwhile, a greater disparity has been noted in the time spent by the UG mentor among the student groups. This is because they were interacting via many other platforms (MS TEAMS channels, virtual meetings and chats, telephonic conversations, etc.) rather than messaging apps. Moreover, it is a noteworthy fact that the existence of introvert and extrovert students and near-peer mentors is a common human behavioral aspect that cannot be overruled [42].

Thus, it has been well understood that this approach of near-peer mentoring has aided students to be highly motivated. With this approach, students were able to communicate with the UG mentors more informally and with ease, than it was with their elder primary mentors (STEM experts); and, it is possibly because the UG mentors were closer to school students' age and could well relate to the challenges/experiences of their academic life. Thus, the UG mentors acted both as guides (who shared knowledge) and as friends (who provided emotional support). In addition, these connections have eventually, aided students to develop a sense of belonging, which is an important criterion for student motivation, retention, engagement, and success in an online course.

In addition, the comparative assessment of the same (research question 2) has allowed us to understand the students' (middle and high school) behavior (response) in an online setup (Figure 4). The results spotlighted the fact that middle school students showed greater rapport and bonding with the UG mentors, compared to the high school students. Similarly, middle school students required more motivation (in terms of encouragement, appreciation, and support) from the UG mentors, than the high school students.

Thus conclusively, this UG near-peer mentoring model has been extremely efficient in helping the students to be curious and self-sufficient to complete their online STEM courses. Though this model has many benefits, the flaws have been explored by a SWOT (strengths, weaknesses, opportunities, and threats) analysis matrix (Table 5) [43]. A SWOT analysis matrix of the online UG near-peer mentoring model, revealing the strengths, weaknesses, opportunities, and threats w.r.t the participants (school-student mentees and UG mentors) has been briefed following. The SWOT analysis matrix has been computed based on the qualitative analysis of mentors-mentees text transcripts, along with the primary and secondary mentors' feedback (refer to Table A2).

**Table 5.** SWOT analysis matrix of the online UG near-peer mentoring model, revealing the strengths, weaknesses, opportunities, and threats w.r.t the participants (school student mentees and UG mentors).

| | |
|---|---|
| **Strength** | • Increased student motivation, engagement, retention, and participation.<br>• Increased student skills like critical thinking, problem-solving, and design thinking.<br>• Informal cum friendly environment for teaching and learning.<br>• Bridged school and university.<br>• Helped students to be self-regulatory, and independent.<br>• Provided a "Teaching experience" to the UG mentor. |
| **Weakness** | • Technical glitches during online set-up.<br>• Difficulty in handling younger students in online mode.<br>• Responsibility of one UG mentor with many student mentee groups.<br>• Difficulty in reaching out to all students simultaneously, asynchronously (off session) by the UG mentor.<br>• Overlapping academic schedules of the UG mentors. |
| **Opportunities** | • Decreased learning losses during the pandemic-mediated educational lockdown.<br>• Ensure "curiosity-intact" among students.<br>• Attract students to STEM specialization and career.<br>• Bridge school and university<br>• Creation of young innovators and early-career scientists. |
| **Threats** | • Unexperienced/introverted UG near-peer mentor finding difficulty in teaching and managing school student mentees.<br>• Online or technical glitches.<br>• Poor collaboration between UG near-peer mentors, students, and STEM experts. |

## 6. Conclusions

In the present era of online education, novel approaches to STEM education should be pondered upon, to motivate and maintain STEM curiosity among young minds. STEM education via the online near-peer mentoring model is one such approach. Many studies have already shown the success of near-peer mentoring models [6–8,44]. but there are limited studies on online near-peer mentoring [14,27]. Thus, as the prominence of online STEM education tends to increase in the contemporary world, we have designed, delivered, and inspected an online near-peer mentoring model, incorporating UG mentors and school student mentees. A similar study by Garcia-Melgar and Meyers (2020) has explained the importance of social and cognitive congruence [14] during such an online mentoring model. In other words, they stressed the social and cognitive relatedness of mentor and mentee for a successful online mentoring relationship. Unlike their study, our study spotlights the eminent roles of the UG mentors during the process of motivating the students. Such an approach is exceptionally beneficial for the school-student mentees, as it surges their motivation, involvement and engagement in an online course. This is crucial as a lack of motivation and engagement is considered one of the most challenging aspects of online education [1].

In this motivationally supportive online mentoring model, the UG students (secondary mentors), have motivated/mentored/guided the school students (middle and high school). The paper has explored various constructive roles of the UG mentors, such as motivating, encouraging, appreciating, supporting (technically and academically), and creating a rapport with the students in an online setup. One of the prominent results of the investigation was the higher amount of motivation required for middle school students when compared to high school students. This might be probably due to younger students' difficulty in accustoming to the technology. Another peculiar observation was the highest amount of motivation required during the first week of the online STEM course, which subsequently decreased in the following weeks. Thus, the UG mentors have proved to be extremely beneficial in igniting cum enlightening the students and driving them to be more curious, self-engaged, and, self-sufficient. Therefore, in other words, this gradual decrease in the interactions or motivation required by the mentees could probably be due to the students becoming more independent. Thus, the findings of the study promote a motivationally supported online environment for greater engagement and self-regulated learning. Thus, we believe that focusing on the motivational aspect of online near-peer mentoring for STEM education is a highly crucial determinant. This would ensure the endurance of students within the STEM pipeline and cultivate their expertise, and help them chase careers in the same. Although the complete dependability and sustainability of this model in today's new normal of online education has to be explored further, our study serves as a perfect opportunity for further investigations in a similar area of education.

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## Appendix A

**Table A1.** Student mentees' feedback form.

| |
|---|
| What did you like the most? |
| What did you like the least? |
| Any suggestions? |

Reference: Alkhair S, et al., (2022). Cultivating STEM interest in high school students through computer-assisted COVID-19 pandemic awareness course. Educational Innovation and Emerging Technologies, 2(2), 28–38. https://doi.org/10.35745/eiet2022v02.02.0003 [45].

**Table A2.** Primary and secondary mentors' feedback form.

| Components of Attitudes | Feedback | Comments |
|---|---|---|
| Cognitive aspect | **About the task**<br>(How well do students understand the task) | |
| Affective and Psychomotor aspect | **About processing the task**<br>(How well did the students complete the task) | |
| | **About presenting the tasks/projects**<br>(How well did the students present the task) | |
| | **Collaboration**<br>How well they performed as a team) | |
| | **Engagement**<br>(How well do each student involve in the course) | |
| | **Any other comments** | |

Reference: Hattie, J., and Timperley, H. (2007). The power of feedback. Review of Educational Research, 77 (1), 81–11 [46].

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