Engagement and Effectiveness of a Healthy Coping Intervention via Chatbot for university students: proof-of-concept study during the COVID-19 pandemic

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Submitted to: JMIR mHealth and uHealth
on: February 15, 2021

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Abstract

Background: College students are increasingly reporting common mental health problems, such as stress, anxiety and depression, and they frequently face barriers to seeking psychological support, because of stigma, cost and availability of mental health services. This issue is even more critical in the challenging time of Covid-19 pandemic. Digital mental health interventions, such as those delivered via chatbots on mobile devices, offer the potential to achieve scalability of healthy coping interventions by lowering cost and supporting prevention.

Objective: To conduct a proof-of-concept evaluation measuring the engagement and effectiveness of Atena, a psychoeducational chatbot supporting healthy coping with stress and anxiety, in a university students' population.

Methods: In a pilot study, 71 university students, 67.6% female (48/71), attending the first year of university during the Covid-19 pandemic, who were on average 20.6 years old (SD 2.4) were enrolled and asked to use the Atena psychoeducational chatbot for 4 weeks (8 sessions, 2 per week), providing healthy coping strategies based on Cognitive-Behavioral Therapy, positive psychology and mindfulness techniques. The intervention program consisted of conversations combined to audio-video clips delivered by the Atena chatbot. Participants were asked to complete web-based versions of the 7-item Generalized Anxiety Disorder scale (GAD-7), the Perceived Stress Scale (PSS-10) and the Five Facet Mindfulness Questionnaire (FFMQ) at baseline and post intervention to assess effectiveness. They were asked to complete the User Engagement Scale (UES-short form) at week 2 to assess engagement with the chatbot and to provide qualitative comments on their overall experience with Atena post intervention.

Results: from the completers analysis showed a significant decrease in anxiety symptoms for participants in more extreme GAD-7 score ranges (t (39) = 0.94, P = .009) and a decrease in stress symptoms (t (39) = 2.00, P = .05) for all participants post intervention. Participants improved significantly also in the Describing and NonJudging scales scores of FFMQ and asked for some improvements in the user experience with the chatbot.

Conclusions: This study shows the benefit of deploying digital healthy coping interventions via chatbots to support university students with higher levels of distress. While findings collected during the Covid-19 pandemic show promise, further research is required to confirm conclusions. Clinical Trial: NA

(JMIR Preprints 15/02/2021:27965)
DOI: https://doi.org/10.2196/preprints.27965

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Methods: In a proof-of-concept study, 71 university students, 67.6% female (48/71), attending the first year of university during the Covid-19 pandemic, who were on average 20.6 years old (SD 2.4) were enrolled and asked to use the Atena psychoeducational chatbot for 4 weeks (8 sessions, 2 per week), providing healthy coping strategies based on Cognitive-Behavioral Therapy, positive psychology and mindfulness techniques. The intervention program consisted of conversations combined to audio-video clips delivered by the Atena chatbot. Participants were asked to complete web-based versions of the 7-item Generalized Anxiety Disorder scale (GAD-7), the Perceived Stress Scale (PSS-10) and the Five Facet Mindfulness Questionnaire (FFMQ) at baseline and post intervention to assess effectiveness. They were asked to complete the User Engagement Scale (UES-short form) at week 2 to assess engagement with the chatbot and to provide qualitative comments on their overall experience with Atena post intervention.
Results: Participants engaged with the Atena chatbot an average of 78 (SD 24.8) times over the study period. 61 over 71 participants completed the first 2 weeks of intervention and provided data on engagement (14.1% attrition), while 41 participants completed the full intervention and the post intervention questionnaires (42.26% attrition). Results from the completers analysis showed a significant decrease in anxiety symptoms for participants in more extreme GAD-7 score ranges (t (39) = 0.94, P = .009) and a decrease in stress symptoms (t (39) = 2.00, P = .05) for all participants post intervention. Participants improved significantly also in the Describing and NonJudging scales scores of FFMQ and asked for some improvements in the user experience with the chatbot.
Conclusion: This study shows the benefit of deploying digital healthy coping interventions via chatbots to support university students with higher levels of distress. While findings collected during the COVID-19 pandemic show promise, further research is required to confirm conclusions.

Keywords: mobile mental health; chatbots; anxiety; stress; university students; digital health; healthy coping intervention; covid-19

Introduction

Rising rates of the adult population and particularly of university students are experiencing symptoms of stress, anxiety and depression [1,2], which are even more exacerbated by the recent restrictions introduced by the COVID-19 pandemic [3,4]. Also, up to 74% of mental health diagnoses have their first onset before the age of 24 [5]. However, about three quarters of the college students who are in need of clinical services do not access them [6], since they have low mental health literacy and do not recognize a need for treatment [7], but also because of their high cost, low availability or attitudinal barriers, such as perceived stigma [8,9]. In recent years, the wider access to digital technology and mobile phones has presented new opportunities for overcoming these barriers, by offering the possibility of delivering digital mental health interventions in a more scalable and convenient way [10,11].

Empirical studies on evidence-based digital interventions for mental health, including those based on Internet Cognitive Behavioral Therapy (I-CBT), have proved that these interventions are effective, feasible and acceptable to users [12,13, 14], although some limitations have been found, mainly regarding their low engagement for users and the low completion rates [15,16]. The integration of human coaching and support in digital mental health interventions can help improve adherence and behavior change outcomes [17,18], although this may reduce the scalability of such solutions. The design and deployment of conversational agents, such as chatbots, as virtual coaching solutions to deliver psychoeducational interventions for mental health and well-being have so far proved ideal to maintain the intuitiveness and naturalness of dialog-based interaction, while exploiting the benefits of full automation [19,20]. These solutions seem to be particularly interesting to deploy at the time of the COVID-19 pandemic, when restrictions to face-to-face social encounters and interaction make it even more difficult to access human psychological support.

The use of chatbots for digital mental health interventions has attracted interest in the design community and a growing number of studies are reporting their acceptability and feasibility for users [20-22], as well as their effectiveness in reducing perceived stress [16-25] and abnormal eating behavior [26], improving symptoms of anxiety [10,23-25],depression [10,24,25] and insomnia [27]. Like previous work and meta reviews on digital mental health interventions for the general adult population and for university students, a main limitation of these studies is their exclusive focus on randomized control trials (RCTs), which prevents a full understanding of the challenges regarding user engagement, uptake and adoption of these solutions [15-28]. More research is needed to understand the user experience and engagement with digital mental health interventions, to not only prove their clinical efficacy, but also to facilitate their successful implementation in real-world settings [25-29].

The objective of this study was to assess the level of engagement and effectiveness of university students' interaction with a psychoeducational intervention delivered by the Atena chatbot over 1 month, to improve their coping and resilience skills during the COVID-19 pandemic. The study design was based on a mixed-method approach and encompassed two phases of the ORBIT framework [30] for intervention design (phase I) and preliminary testing (phase IIa). In phase I the intervention, targets and components were defined in order to specify their clinically relevant effect on users and for refining the intervention components. In phase IIa a proof-of-concept implementation of the digital intervention and chatbot was realized and preliminary tested for engagement and effectiveness with a convenience sample of university students. We hypothesized

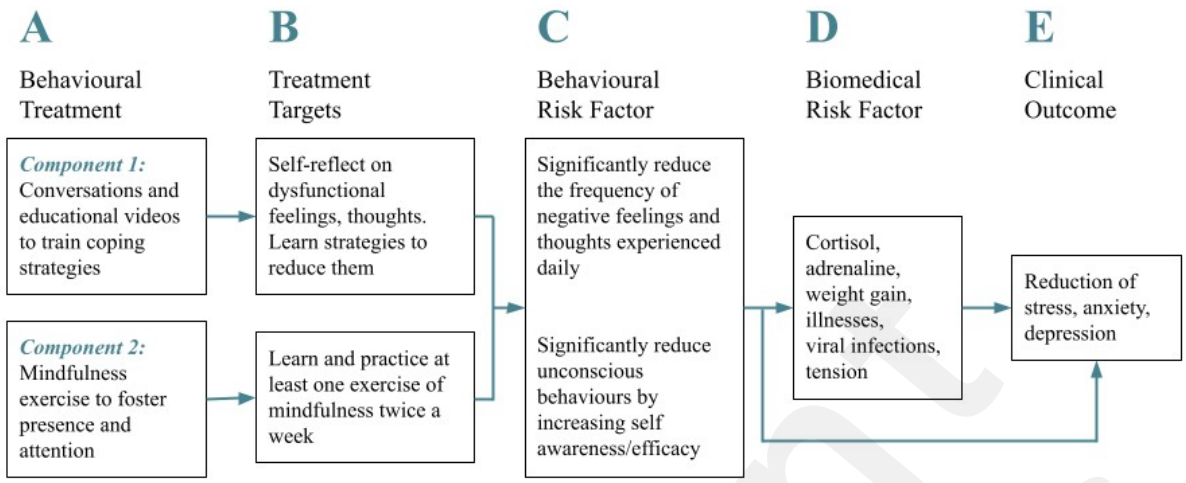
that use of the Atena chatbot over a 1-month period would lead to a reduction in symptoms of stress and anxiety and prove engaging and acceptable to use by students.
To our knowledge this is a first study investigating the potential effect of healthy coping chatbot interventions during the COVID-19 pandemic, a time when the empowerment of stress management skills is much needed by the adult population and, particularly, by university students.

Methods

The Atena Chatbot Design

Atena is a chatbot delivering psychoeducational content for coaching users on coping strategies and on improving their mental well-being by means of conversational dialogs with the coach Atena and audio-video educational materials. It is accessible for free on the Telegram messaging app, available on mobile or desktop devices. The chatbot is built on JavaScript and was developed by the Digital Health Lab at Fondazione Bruno Kessler (FBK) research center.
The digital mental health intervention delivered by Atena is aimed at improving users' well-being by raising self-awareness about one's thoughts and emotions and by suggesting effective coping strategies that can be adopted in facing typical stressful situations, thus promoting mental well-being and preventing mental distress. The full program consists of 8 short sessions (each lasting about 10 minutes) delivered twice a week for 4 weeks. Each session is initiated by the chatbot on a scheduled plan decided by the user during the first session. Users are invited by the chatbot to fill in web versions of psychological symptoms' questionnaires at baseline and post intervention, as well as the user engagement scale at the end of week 2.
The conversations between Atena and the user are informed by evidence-based approaches and intervention strategies of Positive Psychology and CBT, including psychoeducation on self-awareness and self-efficacy, conflict resolution, assertive communication and practical exercises on mindfulness delivered at the end of each session [31,32]. These intervention strategies based on Positive Psychology, CBT and mindfulness practices have been recently deployed by fully automated conversational agents targeting anxiety, stress and depression problems, with promising results in terms of efficacy and acceptability by users [10, 16, 24, 25]. The aim of the conversations is to trigger and support the user to self-reflect on personal thoughts and emotions experienced in daily stressful settings, to learn how to best deploy more functional strategies to overcome difficulties and to better manage stress and anxiety. The intervention program, including the behavioral and clinical targets, as well as the audio-video content were originally developed by a team of 3 clinical psychologists to fit the needs of the general adult population facing stress and anxiety challenges posed by the COVID-19 pandemic (Figure 1). A refinement of the conversations and video materials was then performed by the same psychologists in collaboration with 2 user experience (UX) and behavior change experts in the design team, to adapt the language, videos and chatbot interaction to the needs of the students' target group.

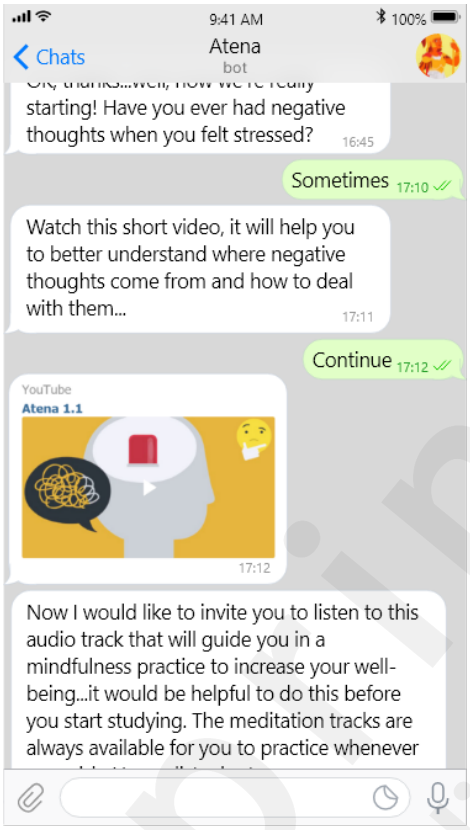
Figure 1. Definition of the healthy coping behavioral intervention and clinical outcome



The Atena chatbot always starts the conversation, upon the scheduled date-time for that session, and the user replies by choosing among a predefined set of answer options. In this way the conversation flow can be customized to sound more relevant and empathic to the user's answers. Each session starts with a short psychoeducational video cartoon, representing typical challenging situations experienced by young characters and the corresponding strategies adopted to cope with them, to mimic relevant settings experienced by the target users, fostering their identification with those settings and their learning. In the final part of the session the chatbot invites the user to perform a mindfulness exercise to favor her presence and attention, by following a coaching voice provided through an audio track (Figure 2).

Upon enrollment users were made aware that the Atena chatbot was not intended to replace professional mental health treatment, but that it was a prototyped digital tool designed to support psychoeducational interventions, going through preliminary testing in this study. In the first session, an introductory video cartoon was also presented to the user by the Atena chatbot to explain the main features, applications and limitations of chatbot technology, in order to facilitate the creation of appropriate expectations towards the digital tool and intervention tested.

Figure 2: Screenshot from session 1 of Atena chatbot



Participants

The Atena chatbot was voluntarily accessed and used by a recruited convenience sample of 71 university students, age range 18-34 (M 20.6, SD 2.4), 67.6% females (N=48/71), attending a Human-Computer Interaction (HCI) course in the first year of a bachelor program at the University of Trento (Italy), who were recruited and invited by SG and RM to access the chatbot via the messaging app Telegram. Participation was on a voluntary basis and the inclusion criteria were the following: i) being a university student attending the first academic year, ii) owning a smartphone with a Telegram account. Atena was designed to offer coaching conversations and audio-video materials to improve coping skills and well-being, also by means of mindfulness meditation. Students used Atena between mid-October and November 2020, a period affected by the second wave of COVID-19 pandemic in Italy, with restrictions to citizens mobility, social distancing and blended learning recommended at the university. All users were Italian speakers located in the North-East of Italy.

Measures

Perceived Stress Scale (PSS-10)

The PSS-10 is a brief self-report constituted by 10 items rated on a 5-point Likert scale, ranging from 0 (never) to 4 (very often). The PSS measures the perception of stress, i.e., the degree to which

situations are appraised as stressful, by asking respondents to rate the frequency of their thoughts and feelings related to situations that occurred in the recent time [33] (*e.g., in the last month, how often have you felt nervous and stressed?*). Scores are evaluated as follows: low (score 0-13), moderate (score 14-26) and high (score 27-40). PSS is one of the most widely used psychological instruments, reporting good psychometric properties. In the current study Cronbach's alpha was .84.

Generalized Anxiety Disorder (GAD-7)

The GAD-7 [34] is a 7-item self-report scale based on a 4-point Likert scale, ranging from 0 (not at all) to 3 (nearly every day). The GAD is used to assess anxiety symptoms over the past 2 weeks *(e.g., how often have you been bothered by feeling afraid something awful might happen?)*. The total scores are divided into four categories: none (0–4), mild (5–9), moderate (10–14) and severe (higher than 15) symptoms [23, 24]. In the present study, Cronbach's alpha was .86.

Five Facet Mindfulness Questionnaire (FFMQ)

The Five Facet Mindfulness Questionnaire (FFMQ) [35] is a 39-item self-report measure, evaluated on a 5-point Likert scale from 1 (never or very rarely true) to 4 (very often or always true) to assess the tendency to be mindful in daily life. The five facets are as follows: Observing (8 items, *e.g., when I'm walking, I deliberately notice the sensations of my body moving*), Describing (8 items, *e.g., I'm good at finding words to describe my feelings*), Acting with awareness (8 items; *e.g., when I do things, my mind wanders off and I'm easily distracted*), Nonjudging (8 items, *e.g., I criticize myself for having irrational or inappropriate emotions*), and Nonreactivity (7 items; *e.g., I perceive my feelings and emotions without having to react to them*), and a total score. Facet scores range from 8 to 40 (except for the nonreactivity facet, which ranges from 7 to 35), with higher scores indicating more mindfulness. The sum of the direct and reverse-scored items gives the total score (from 39 to 195). In the current study, Cronbach's alphas were .74 for Observing, .92 for Describing, .85 for Acting with awareness, .91 for Nonjudging, .79 for Nonreactivity, and .84 for the total score.

User Engagement Scale-Short Form (UES-SF)

The User Engagement Scale Short Form [36] is a self-report comprising 12 items rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The UES measures the main determinants of adherence and, in particular, it assesses 4 factors: Perceived Usability (PU) (*e.g., using Atena was frustrating)*, Aesthetic Appeal (AE) (*e.g., Atena appealed to my senses)*, Focused Attention (FA) (*e.g., I lost myself in this experience),* and Reward (RW) (*e.g., this experience was rewarding*) and a total score. The RW factor is a summary of three factors from the original UES: *endurability*, a measure of how successful the interaction was and the likelihood of recommending the application to others; *novelty*, a measure of curiosity and interest; and *felt involvement*, a measure of the feeling of being "drawn in" and having fun [36]. Scores for each of the four subscales can be calculated by adding all the items related to their factor and dividing them for the total items.
A back translation was conducted, thus all scales were translated into Italian and validated for use within this population. In the current study, Cronbach's alphas were .66 for PU, .66 for FA, .52 for AE, .87 for RW and .83 for the total scale.

Procedures

After signing and submitting their digital consent form, users were instructed on how to fill in the web-based versions of the PSS-10, the GAD-7 and the FFMQ questionnaires by using an alpha numeric pseudonymization code decided by them and then to access the Atena chatbot on Telegram

app. In the first session with the chatbot users were welcomed and provided with the introductory video on chatbot technology. They were also asked to set a desired day/time for their 2 weekly sessions with Atena, according to their preferences.
The chatbot prompted the user to start a session at the scheduled day/time, but the user was free to pause, continue or discontinue the session at any time.
At the end of week 2 (session 4) the users were invited by the chatbot to fill in the UES-SF questionnaire to assess their early engagement with the intervention and collect any free comment about their UX with the chatbot during the first two weeks of interaction.
At the end of week 4 (session 8) the users were invited by the chatbot to fill in again the PSS-10, GAD-7 and FFMQ questionnaires. The chatbot thanked them for their participation in the study and recommended to continue exercising with the psychoeducational content delivered in order to improve their coping skills. Four weeks after the end of the study, participants were also asked to fill in a brief online survey to report what they mostly liked and disliked of their experience with Atena, and whether they had continued to practice any of the exercises provided during the intervention with/out the support of Atena in the last 4 weeks. No monetary incentive was provided for participating in this study.

Ethics and Informed Consent

The study was reviewed and approved by the Fondazione Bruno Kessler (FBK) Institutional Ethics Board, since it involved a non-clinical population. Participants indicated their consent for their pseudonymized data to be used for research purposes after reading an information sheet.
All study data were collected by the Digital Health Lab of FBK. Because of deidentification of all data transmitted between the Atena chatbot and the user, usage data were not linked to specific research participants and are therefore reported in aggregated format.

Statistical Analyses

Statistical analyses were performed using R [37] and SPSS Statistics, Version 24.0 [38].
The Shapiro test was carried out to evaluate the normal distribution of the variables included in this study, such as the GAD-7 and the PSS-10 questionnaire (i.e., anxiety and stress symptoms, respectively), the five subscales of the FFMQ, as well as its total score and the UES-SF questionnaire.
The main descriptive analyses (i.e., mean, standard deviation, frequencies) were performed in order to assess the demographic characteristics of the overall sample (i.e., age and gender), as well as the GAD-7 and the PSS-10 (i.e., anxiety and stress symptoms, respectively), the five subscales of the FFMQ and its total score, and the UES-SF questionnaire.
Paired sample t-test was conducted to evaluate differences between pre-and post-intervention concerning the GAD-7 and the PSS-10 (i.e., anxiety and stress symptoms, respectively), the five subscales of the FFMQ and its total score. A p-value equal or less than .05 was considered statistically significant.
An independent sample t-test was run in order to evaluate differences between pre-and post-intervention considering two clusters of users' symptoms, extreme *vs* moderate ranges, as follows: (1) minimal and severe, and (2) mild and moderate referring to the GAD-7 and the PSS-10 questionnaire scores. A p-value equal or less than .05 was considered statistically significant.
Participants' responses to open-ended questions from the online final survey were analyzed by SR and SC using thematic analysis and were reported as frequencies. Data were analyzed thematically using an inductive (data-driven) approach guided by the procedure outlined in [39]. Data codes were generated systematically, then collated into themes and applied to the entire dataset to generate

frequencies.

Results

Participants Demographic Characteristics

All the variables included in the analyses are normally distributed.
As displayed in Table 1, at baseline the overall sample (N = 71) shows a mean close to the moderate range in the GAD-7 and the PSS-10 scores.
More specifically, as regards the level of anxiety measured through the GAD-7, 35.2% students (25/71) were in the ‘mild’ range (i.e., score 5-9), 31% (22/71) in the ‘moderate’ (i.e., score 10-14) and 19.7% (14/71) in the ‘severe’ range (i.e., score higher than 15). Only 14.1% (10/71) students were in the ‘minimal’ range (i.e., 0-4). Regarding anxiety symptoms among gender, the analyses show that males experience mild anxiety symptoms while females show moderate anxiety symptoms.
As regards stress symptoms evaluated through the PSS-10, 64.8% (46/71) of the sample was in the ‘moderate’ range (i.e., score 14-26), 7% (5/71) was in the ‘low’ range (i.e., score 0-13) and 28.2% (20/71) shows ‘high’ scores (i.e., score 27-40). Both males and females display moderate stress symptoms.
Regarding the FFMQ scores, participants had an average mindfulness total score of 119.96 (SD 16.99), with males scoring higher with an average of 126.26 (SD 19.22) and females with an average of 116.93 (SD 15.10).

Table 1. Participants Demographic Characteristics

	The overall sample (N = 71)		Male (N = 23)		Female (N = 48)	
	Mean	SD[d]	Mean	SD	Mean	SD
GAD-7[a]	9.92	4.88	9.26	4.66	10.23	5.01
PSS-10[b]	22.46	6.68	20.78	6.65	23.27	6.61
Observing	23.54	5.81	23.30	5.78	23.15	5.89
Describing	23.55	7.16	25.00	7.11	22.85	7.15
Act with Awareness	25.85	6.10	26.30	6.17	25.63	6.12

Nonjudging	26.04	7.95	28.13	6.34	25.04	8.50
Nonreacting	18.44	4.40	20.39	5.26	17.50	3.61
FFMQ[c] total score	119.96	16.99	126.26	19.22	116.93	15.10

[a]Generalized Anxiety Disorder-7
[b]Perceived Stress Scale-10
[c]Five Facet Mindfulness Questionnaire
[d]Standard Deviation

Attrition

Participants who provided data on the user engagement questionnaire at the end of week 2 were 85.9% (61/71), representing an overall attrition rate of 14.1%. Participants who completed the post-intervention questionnaire were 57.74% (41/71), representing an overall attrition rate of 42.26%. Dropout was higher in the ‘minimal’ and ‘mild’ ranges of the GAD-7 questionnaire (50% and 44%, respectively), lower in the ‘moderate’ and ‘severe’ ranges (40.9% and 35.7%, respectively). Moreover, dropout was higher in the ‘moderate’ and ‘high’ ranges of the PSS questionnaire (66.7% and 26.7%, respectively), and lower in the ‘low’ ranges (6.7%).

The User Engagement with the Atena chatbot

Table 2 shows the result of the user engagement with the Atena chatbot as measured by the UES-SF questionnaire at week 2. 61 participants were in agreement with the PU factor, which measures the affective (frustration) and cognitive (effortful) aspects as a result of the interaction. Participants answered in neutral way as regards: (i) the total UES-SF score, (ii) the AE factor, measuring the sensory and visual appearance of the interface, (iii) the RW factor, measuring the hedonic aspects of experience, the felt involvement, the overall success of the interaction, and the willingness to engage with the chatbot in the future. Lastly, as regards the FA factor, which evaluates the focused concentration, absorption, and temporal dissociation, participants were in disagreement. Since participants were students attending an HCI course, their expectations regarding the User eXperience (UX) and the quality of the user engagement with the chatbot might have been higher if compared with students attending other higher education subjects. However, it should be considered also that participants were attending the first semester of their bachelor program, so their expertise in the field of technology design was still quite limited and comparable to that of other students in their same age group.

Table 2. User engagement with the chatbot measured by the UES-SF questionnaire (N = 61)

	Mean	SD[b]
Focused Attention	2.73	.79
Perceived Usability	4.28	.66
Aesthetic Appeal	3.09	.65
Reward Factor	3.15	.84
UES-SF[a] total score	3.15	.84

[a]Standard Deviation
[b]UES-SF=User Engagement Scale-Short Form

Preliminary Efficacy from Completer Analysis

There was a reduction of participants in the 'severe' GAD-7 range at post-intervention (from 19.7% to 9.8%, Table 3). Also, 7 participants who were above the clinical cut-off score for GAD-7 of ≥8 at baseline moved below this cut-off at post-intervention (17.1%).
The independent t-test between pre-and post-intervention between the two clusters of students, cluster 1 with extreme symptoms, cluster 2 with moderate symptoms, showed a significant difference (t (39) = 0.94, *P* = .009) among anxiety ranges (i.e., GAD-7) in cluster 1, with a decrease of symptoms between pre- (M = 12.14, SD 6.88) and post-intervention (M = 10.07, SD 4.58). No other significant difference between pre-and post-intervention was found.

Table 3. Classification of anxiety symptoms pre- and post-intervention (% of participants in each classification using GAD-7)

	Pre (N =71)	**Post (N=41)**
Minimal	10 (14.1%)	5 (12.2%)
Mild	25 (35.2%)	17 (41.5%)
Moderate	22 (31%)	15 (36.6%)

Severe	14 (19.7%)	4 (9.8%)

In line with the GAD-7 results also the PSS-10 scores showed an increase in the low range and a decrease in the high one (Table 4). This might indicate a positive effect of the intervention on participants being in the more extreme scales ranges with respect to those in the intermediate ranges. Table 5 shows that the levels of stress symptoms (i.e., PSS-10) present a significant decrease ($t(39) = 2.00$, $p = .05$) between pre-and post-intervention. Moreover, the means of the subscales Describing and Nonjudging, as well as the means of the total score of the FFMQ, show a significant increase ($p < .05$) between pre-and post-intervention.

Table 4. Classification of perceived stress symptoms pre- and post-intervention (% of participants in each classification using PSS range scores)

	Pre (N=71)	**Post (N=41)**
Low	5 (7%)	5 (12.2%)
Moderate	46 (64.8%)	27 (65.9%)
High	20 (28.2%)	9 (22%)

Table 5. Paired t-test between pre- and post-intervention (N=41)

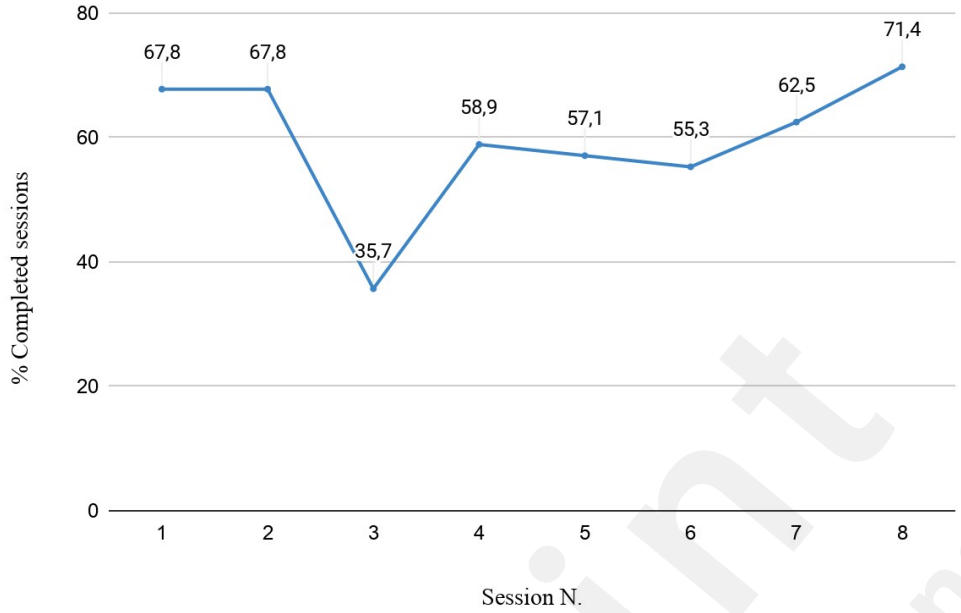
Paired t-test	Pre- Mean (SD[d])	Post Mean (SD)	Mean Differences (SD)	t	Sig. (2-tailed)
GAD-7[a]	10.49 (4.62)	9.29 (0.72)	1.19 (4.14)	1.85	.072
PSS-10[b]	22.49 (6.52)	20.83 (0.97)	1.66 (5.30)	2.00	.050*
Observing	23.15 (5.84)	23.37 (6.50)	-.22 (5.43)	-.259	.797
Describing	23.05 (7.29)	24.98 (6.03)	-1.92 (5.29)	-2.33	.025*
Act with Awareness	26.15 (6.56)	26.12 (6.99)	.02 (6.27)	.03	.980
Nonjudging	25.85 (7.78)	28.02 (7.46)	-2.17 (6.09)	-2.28	.028*
Nonreacting	18.41 (4.01)	18.66 (4.85)	-.24 (4.55)	-.34	.733
FFMQ[c] total score	119.49 (16.56)	147.27 (19.67)	-27.78 (16.74)	-10.62	.000*

[a]Generalized Anxiety Disorder-7
[b]Perceived Stress Scale-10
[c]Five Facet Mindfulness Questionnaire
[d]Standard Deviation
*p<.05

Use of the Chatbot

Participants interacted with the Atena chatbot an average of 78 times (SD 24.8, median 81; range 5-158) over the 4-week period. The number of uncompleted sessions was an average of 3.1 (SD 2.3) out of 8 overall sessions. In Figure 3 it is reported a graph with the percentage of completed sessions over the 4 weeks period, showing that engagement and willingness to complete a session was higher during the first and the last weeks of the study.

Figure 3. Percentage of completed sessions over the study 4 weeks' duration



Qualitative Results

Participants providing qualitative data in the follow-up survey were 17 students, 64.7% females (N=11), and 35.3% males (N=6).

Three main themes with related subthemes were identified (Table 6). They were “content” with the subthemes: learning, reflection, multimedia, routine, mindfulness, motivation, originality and repetitiveness. “User experience” with the subthemes: sense of reality, interaction and flexibility. “Tasks” with the subthemes: notification and availability.

Content

In terms of content, what students liked most was the availability of videos instead of text-based dialogs only in the interaction with the chatbot (*It was nice to have the possibility of accessing videos and not just using text, that might be boring)*. However, one participant suggested that videos should be improved from a graphic design point of view (*What I liked less were the videos. They were interesting, but I think they should be improved in terms of graphics and visuals in order to be more engaging for users).*

Some students appreciated the opportunity to learn new things (*I appreciated tips provided during the course, which were very interesting and also useful for learning new skills)*, to approach the mindfulness practice *(I find the bot an excellent first opportunity to start mindfulness practices, especially for those who - like me - can never find time to stop and breath and have never tried anything like this before..)* and they appreciated the originality of the exercises *(The originality of the exercises, in my opinion, is very important to foster change in people and help them).*

One student suggested that the chatbot questions should be more variated in format so as not to be too repetitive (*In my opinion, questions should change over time: “how are you” should be asked in a more nuanced way, otherwise it sounds repetitive. I suggest, if possible, to vary the dialogs with the user, especially the welcoming messages)*.

User experience

Regarding the user experience, one student reported that s/he liked most the feeling of real-life interaction with the chatbot (*First of all I appreciated the continuity of the short course with the*

chatbot, the interactions were well thought out and articulated, it felt like chatting with a real person). Some students, however, reported some critics regarding the user-chatbot interaction and gave some suggestions for future improvements *(The interaction with Atena should be more personalised based on the user's answers, sometimes the answering options did not take into account the different nuances of mood).*

Tasks

In the task theme participants' remarks mainly concerned the chatbot notifications and lack of reminders to resume a session when the user was interrupted by some other task (*I often didn't have time to watch the videos at the scheduled time, then I forgot to resume them because there was no reminder).* The possibility of having available in the chat the materials provided by Atena was much appreciated *(I can watch videos again whenever I like).*
Eight out of the 17 students who provided qualitative data (i.e., 4 females and 4 males), reported that they accessed the Atena videos and materials again, also after the 1-month study duration.

Table 6 Participants' themes presented as main themes, subthemes and their quotes.

Main theme	Subtheme	Participant's quotes
Content	Learning	*I enjoyed learning about new forms of interaction and their applications. (Participant 3)* *I appreciated tips given during the course, since they were very interesting and also useful for learning new skills. (Participant 10)*
	Reflection	*Reported topics were all interesting and quick to address. I spent very little time with the chatbot but I think I got some food for thought. (Participant 1)*
	Multimedia	*I liked the guided meditation videos. (Participant 5)* *I really liked the relaxation videos. (Participant 7)* *It was nice to have the possibility to access videos and not just texts, that can be boring. (Participant 8)* *I enjoyed the guided meditation videos. (Participant 13)* *What I liked most were the mindfulness and motivational videos. (Participant 16)* *Videos were long and I often tended to quit them before the end. (Participant 3)* *Videos often recommended walking or covering distances, which made it difficult to perform the task for people like me who live in a small indoor place (I often did not have the possibility or desire to move outdoor). (Participant 9)* *What I liked less was the videos. They were interesting, but I think they should be improved in terms of graphics and visuals in order to be engaging for users. (Participant 10)*

		Unfortunately receiving videos for me had become a pleasant habit, so when it went over it looked like a sudden interruption to me (Participant 16)
	Routine	
	Mindfulness	*Breathing tips, calm tone of voice put me in a good mood, dialogs were motivating and relaxing. (Participant 9)* *I find the bot an excellent first opportunity to practice mindfulness, especially for those who - like me - can never find the time to stop and breathe and have never tried anything like this before. (Participant 13)*
	Motivation	*Low incentive. (Participant 2)* *It didn't appeal me so much, so I struggled to be constant. (Participant 15)*
	Originality	*The originality of the exercises, in my opinion, it is very important to foster a change in people to help them. (Participant 6)*
	Repetitiveness	*In my opinion, questions should vary over time: "how are you" should be asked in a more nuanced way, otherwise it sounds repetitive. I suggest, if possible, to vary the dialogs with the user, especially the welcoming messages. (participant 16)*
User Experience	Sense of reality	*First of all, I appreciated the continuity of the short course with the chatbot, the interactions were well thought out and articulated, it felt like chatting with a real person. (Participant 1)*
	Interaction	*I would have liked to have more dialogs with the chatbot and less external interaction (YouTube video). (Participant 1)* *I would rather prefer to interact and chat whenever I wish, and not only on fixed days. (Participant 8)* *The interaction with Atena should be more personalized based on the user's answers, sometimes the answering options did not take into account the different nuances of mood. (Participant 9)* *Interactions could only take place on the days agreed upon at the outset (Participant 13)*
	Flexibility	*I really liked being able to have flexibility in the scheduling. (Participant 2)*

		Notifications reminding people to take the test. (Participant 4)
		I feel satisfied. My only remark is about the notifications in the dialog flow, which tended to be overlooked. (Participant 4)
Tasks	Notification	*Not having time when the message arrived and then forgetting to do the exercises. (Participant 5)*
		Atena sent me notifications when it was not suitable for me (despite I chose my scheduling options) and then I forgot to do the activity. (Participant 7)
		It would be nice to specify at the very beginning when an activity requires places larger than a room or also to be outdoor. (Participant 9)
		I often didn't have time to watch videos at the scheduled time, then I forgot to resume them because there was no reminder. (Participant 15)
	Availability	*I can watch videos again whenever I like. (Participant 11)*
		The scheduling options, in my opinion, should be more restrictive, or maybe deadlines could be set for some tasks. (Participant 6)
		The videos made it difficult to me to find enough time to watch them. (Participant 12)

Discussion

Results from this preliminary evaluation of the Atena chatbot intervention indicate that healthy coping psychoeducation can be effectively deployed to university students and bring positive effects especially on those who are more in need of psychological support to cope with stress and anxiety symptoms. Our results are in line with recent studies targeting the same population, showing that online stress management interventions are more effective for students with higher levels of stress, anxiety and depression [40,41]. Higher engagement and less attrition rates were also observed in those students in our sample having more severe levels of anxiety at baseline. This is a very promising result for implementing future anxiety prevention and management solutions to be delivered during the COVID-19 pandemic and beyond. Results also showed a significant improvement in the capacity of participants to describe and accept their emotions, which can be an effect of the mindfulness practice and self-reflection elicited by the conversations with the chatbot. Training on this kind of skills may be particularly needed by the university student population and could bring positive effects on their mental well-being.

The baseline levels of stress and anxiety in our participants were significantly higher than those expected in the same population of university students by previous research [42-44], as well as in the general population [45]. Previous studies analysing mental health of university students found lower levels of anxiety and stress symptoms, evaluated through the GAD-7 and the PSS-10 questionnaires, compared to those of our sample of university students [42-44]. This is not surprising since the COVID-19 pandemic had a worsening effect on the general population and on university students in particular: a research conducted on Italian university students to identify psychological consequences of the living conditions during the COVID-19 lockdown, reported high levels of anxiety and stress, concentration disorders, psychosomatization and, in several cases, reactivation of trauma and worsened sleep quality [46]. Moreover, from the time of our baseline assessment until the end of our study the COVID-19 epidemic in Italy reached higher peaks of infections, which required more severe restrictions to be introduced in schools/universities (full online teaching) and in citizens' everyday life. It is likely that students experiencing more severe symptoms of anxiety felt more motivated to engage with the Atena chatbot and found it a more convenient solution to access psychoeducational support, by avoiding, at the same time, stigma and possible difficulties in accessing mental health services.

Overall, our quantitative and qualitative findings are aligned with recent chatbot evaluation studies [10, 23-25] and inform our design decisions for future developments. Results regarding attrition rates during the study, user engagement as well as our qualitative findings suggest that our proof-of-concept needs to be further refined to fully meet the requirements and preferences of the target users before being ready for RCT evaluations. Our analysis indicates that the engagement and attractiveness of a chatbot-based mental health intervention for university students might wear off or reduce significantly after two weeks of interaction, requiring deeper levels of engagement through conversation and rewarding feedback by the chatbot in order to maintain users' interest and commitment during the intervention. This might be particularly useful for supporting adherence of less motivated users, such as the ones with mild to moderate levels of stress and anxiety. Our study contributes also to shed light on what might be the ideal length, frequency or intensity of digital mental health interventions for non-clinical populations. The duration and intensity of our intervention was sufficient to provide psychoeducational support to students without interfering too much with their daily life commitments and it was also effective in triggering more self-reflection and mindfulness practice in the follow-up period. This might be interpreted as a signal of user empowerment and desired behavior change, although more research is needed to confirm this interpretation.

Limitations

This study presents some limitations that affect generalizability of the findings. It reports data from preliminary evaluation of a proof-of-concept chatbot intervention targeting a homogeneous population of university students without a control group. Although the findings on user engagement and preliminary effectiveness of the intervention are promising and aligned with previous research, further testing by means of controlled trials should be conducted to confirm any conclusion about efficacy and to verify its maintenance at follow-up. However, the evidence presented from students' responses and feedback to the intervention confirm the importance of deploying user-centered methodology in the iterative design and refinement of these interventions before investing additional resources in conducting more rigorous efficacy testing.

Another limitation is related to our method of collecting objective data on users' engagement and interaction with the chatbot intervention during the study. Since our log data were deidentified, it was more difficult to assess any difference among users in how deeply they focused attention and self-reflected upon the psychoeducational videos' contents and chatbot suggestions during each session. Although we could derive some information on users' satisfaction with these contents from participants' qualitative comments, a more complete and objective monitoring of users' behavioral interaction with the intervention's components would be preferable to deploy in future studies.

Finally, the study was conducted during the second wave of the COVID-19 pandemic in Italy, characterized by the introduction of increasingly more rigid restrictions to social behavior and educational practices that might have strongly impacted the mental well-being of our participants and reduced the positive effect of our intervention. However, the challenging contextual setting in which our intervention was deployed can also be considered a point of strength of the contribution provided by this study, offering interesting insights for the future wider deployment of digital mental health interventions in challenging conditions.

Conclusion

The study further extends previous research on the use of chatbot-based interventions for healthy coping with stress, confirming their effectiveness in supporting university students with higher levels of distress. Although the generalizability of the reported findings should be viewed with caution, since no control group was involved and the intervention was deployed during the COVID-19 pandemic, these preliminary findings are interesting for inspiring the future design of digital mental health interventions for university students and public health.

Author contribution

SG, SR and GB contributed substantially to the conception and design of the study, the acquisition of data, and writing of the paper. SF and SC provided critical review and significant contribution to the manuscript. RM and MM contributed to the development of the Atena chatbot and to the acquisition of the log data. All authors contributed to the article and approved the submitted version.

Acknowledgments

Special thanks to the students who participated in the study. Thanks also to Letizia Esposti and Griselda Mahmutaj for their support and comments during the study.

Conflicts of Interest

None declared.

Abbreviations

AE = Aesthetic Appeal
CBT = Cognitive Behavioral Therapy
FA = Focused Attention
FBK = Fondazione Bruno Kessler
FFMQ = Five Facet Mindfulness Questionnaire
GAD-7 = Generalized Anxiety Disorder-7
HCI = Human Computer Interaction
M = Mean
ORBIT = Obesity-Related Behavioral Intervention Trials
PSS-10 = Perceived Stress Scale-10
PU = Perceived Usability
RCTs = Randomized Control Trials
RW = Reward
SD = Standard Deviation
SPSS = Statistical Package for Social Science
UES-SF = User Engagement Scale-Short Form
UX = User Experience

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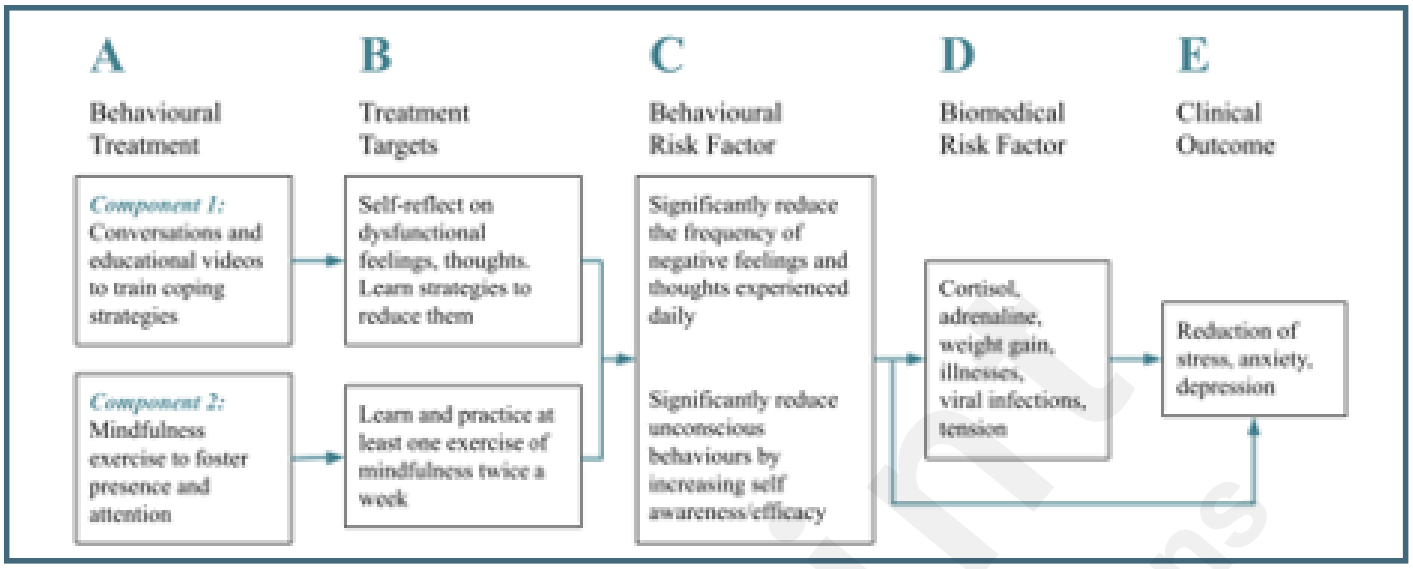
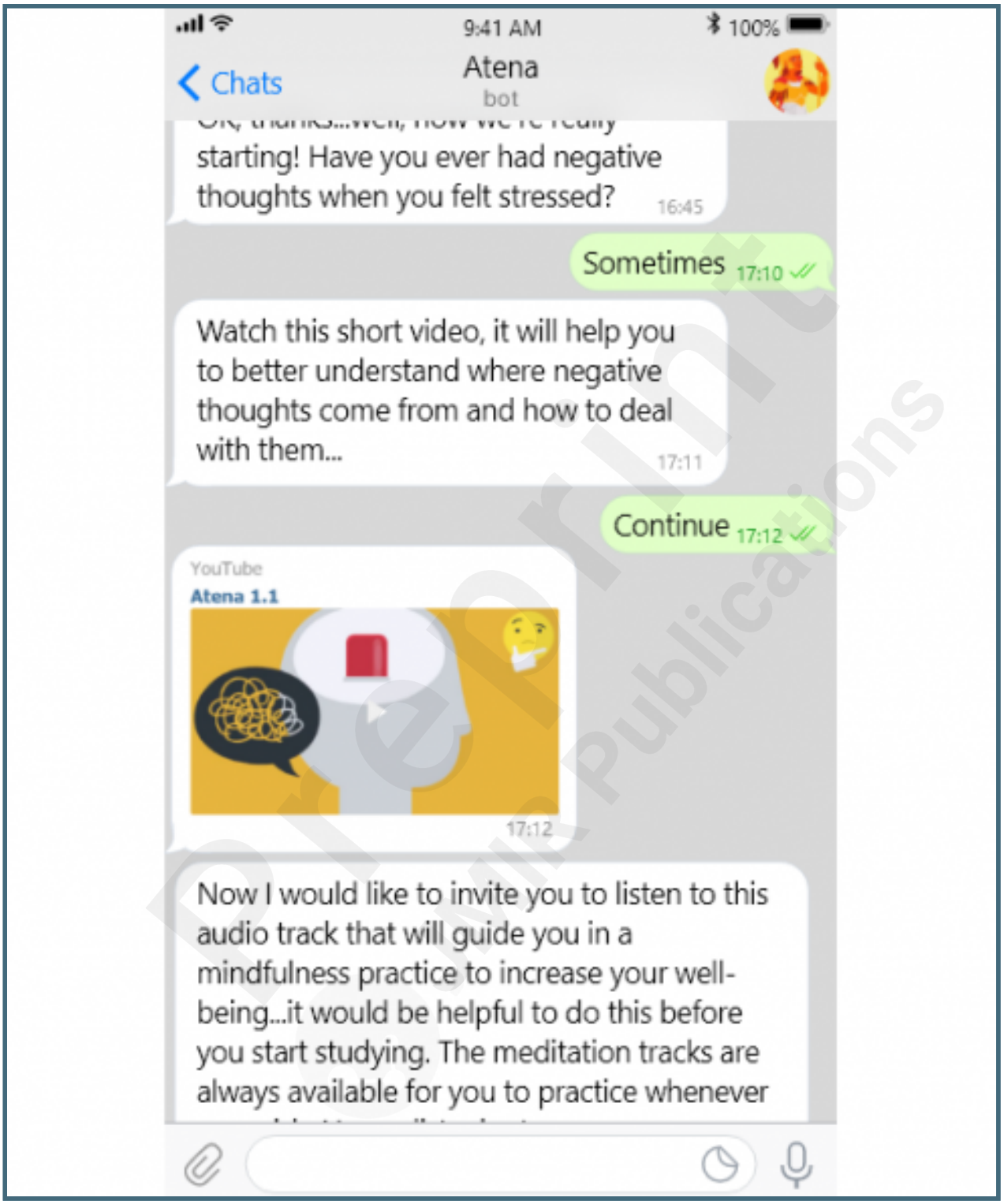
Supplementary Files

Figures

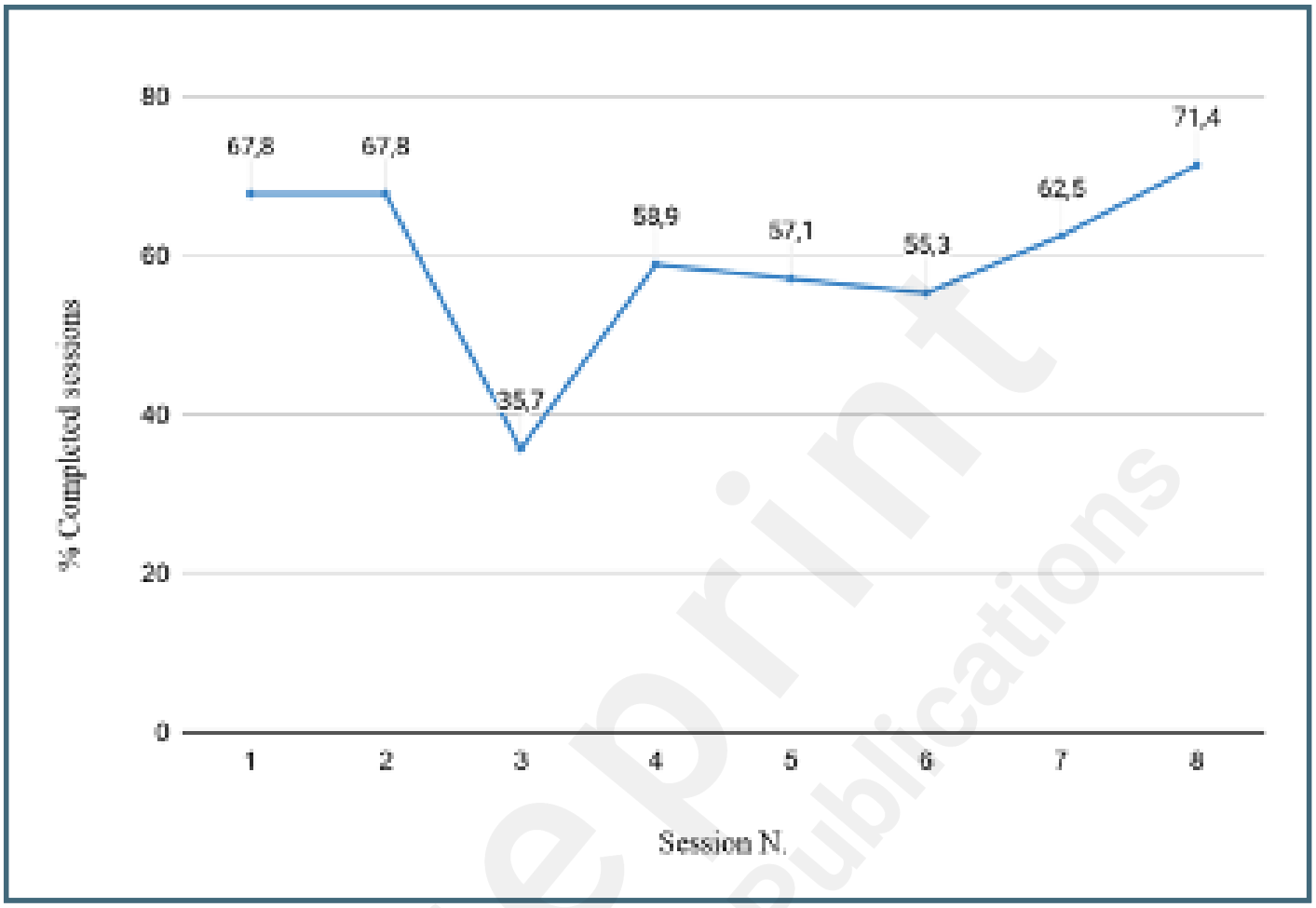
Definition of the healthy coping behavioral intervention and clinical outcome.



Screenshot from session 1 of Atena chatbot.



Percentage of completed sessions over the study 4 weeks' duration.



TOC/Feature image for homepages

Student using the Atena chatbot.