

Usability of graphic medicine as an educational tool among psychology students: quasi-experimental study

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Abstract

Background

Teaching and learning methods in psychology programs must address the complexity of mental health processes and meet the evolving needs of the new generations of psychology students. Graphic medicine offers a visual and immersive approach that can improve engagement, reflection, and empathy. This study aimed to evaluate the usability of mental health-focused graphic novels as educational tools for psychology students.

Methods

A quasi-experimental study was conducted with 158 psychology students of the University of Málaga. The intervention consisted of reading pre-selected excerpts from graphic novels on mental health. Usability and content validity of the graphic novels were assessed after the intervention (post-only), while changes in emotion, motivation, and enjoyment were evaluated using a pre–post comparison. Data were analyzed using the Wilcoxon signed-rank test and thematic analysis.

Results

The graphic novels showed Good Attractiveness (mean = 1.82), Above Average Pragmatic quality (mean = 1.68), and Good Hedonic quality (mean = 1.75). Significant increases were found in motivation to learn about mental health (4.45 vs. 4.57, $p = 0.011$), and motivation (3.08 vs. 3.90, $p < .001$) and enjoyment (3.14 vs. 3.89, $p = .001$) toward reading mental health graphic novels.

Conclusions

Findings highlight the potential of mental health-focused graphic novels as innovative resources for training future psychologists. **Trial registration:** NCT07192445. 25-09-2025.

Background

Traditional educational approaches, such as lectures or written materials like textbooks, while effective for transmitting theoretical knowledge, are often insufficient in the field of psychology for addressing complex topics, such as mental health experiences, and fostering advanced skills, such as empathy (Dunn et al., 2013).

For their future professional practice, psychology students must develop the ability to explore, understand, and acknowledge the personal narratives of mental health experiences from the perspective of service users. This competence requires going beyond the restrictive boundaries of merely analyzing

facts and empirical data provided by verbal communication and paying close attention to non-verbal elements, such as facial expressions or body posture, which together enrich the construction of knowledge and strengthen therapeutic relationships. Without engaging with these multidimensional aspects of human experience during their education, students may struggle to translate theoretical knowledge into effective, empathetic clinical practice (van Berkhout & M Malouff, 2016).

This challenge is compounded by the distinct learning styles, preferences, and needs of new generations of psychology students. As revealed by a recent systematic review, Generation Z healthcare students engage more with active, sensing, visual, and sequential learning styles than with reflective, intuitive, verbal, and global ones. They prefer creative approaches, such as storytelling and images, over traditional textbooks. Moreover, they tend to maintain focus for shorter periods and often show less-developed social skills. Consequently, conventional teaching methods may reduce student engagement, and limit opportunities for effective learning. This highlights the need for meaningful learning strategies that are congruent with Gen Z students' learning styles and actively involve them in the construction of knowledge, fostering deeper comprehension and enhanced interpersonal skills (Shorey et al., 2021).

In this context, graphic medicine offers a learning approach well aligned with these preferences, combining visual narratives in comics, graphic novels, and illustrations. By presenting mental health experiences in a format that blends text and imagery, integrating symbols and metaphors, it can make abstract concepts more tangible and relatable, bridge the gap between theoretical content and real-life application, raise attention, and stimulate empathy ultimately supporting the development of both professional competence and human-centered care (Anderson et al., 2016).

These resources promote introspective reflection by presenting stories that allow students to identify, connect, and learn from the experiences of others. Several processes have been identified regarding reading from an aesthetic perspective, which in the field of education could be articulated as follows. First, through "recognition", students engage and empathize with characters or situations, recognizing the experiential dimensions of mental health challenges. Second, through "integration", they reflect critically on these narratives and relate them to their prior knowledge developing a professional perspective. Third, through "application" the insights derived from the narratives strengthen their ability to identify similar experiences in their future clinical practice (Pollard, 2021).

Research in this field shows that graphic medicine in healthcare professional education has a high potential for refining observational skills, improving knowledge, enhancing professional identity formation, and fostering a more comprehensive and empathic therapeutic relationship (Anderson et al., 2016; Noe & Levin, 2020).

A recent scoping review on the use of graphic novels and comics with medical students found that graphic medicine can contribute to achieving cognitive learning outcomes, as well as developing soft skills and professionalism (Consorti et al., 2023). Similarly, research in nursing education has shown its value for increasing knowledge (Lesińska-Sawicka, 2023) and helping engage in critical reflection and with challenging theoretical concepts (Williams et al., 2024). However, some studies indicate that the

effectiveness of graphic medicine in the training of mental health professionals may depend on prior experience with this type of material, and that sociocultural barriers, such as prejudices toward comics or illustrations, could limit its impact in certain contexts (Priego & Farthing, 2020)

In summary, despite the growing body of research over the last two decades regarding the potential of graphic medicine as an innovative and effective tool for enhancing education among health care professionals, studies focused on psychology students remain limited.

Methods

Aim

The main aim of this study was to evaluate the usability of mental health graphic novels as educational tools for psychology students. Secondary aims were to analyze their emotional, motivational, attitudinal, and perceptual responses towards the graphic novels.

Design

A quasi-experimental study was carried out combining pre-post and post-only measures.

Setting

The study was conducted at the Faculty of Psychology at the University of Malaga, specifically with second-year Psychology students studying Psychopathology. Students were excluded if they had language barriers or had severe reading or comprehension difficulties.

Recruitment

The student recruitment process was carried out through the collaboration with the teachers. Participation in the study was voluntary. The research team informed the entire student body about the study through the Information Sheet (objectives, methodology, and ethical aspects) and requested the signature of the Informed Consent. Quota sampling was used to establish subgroups for each selected graphic novel.

Intervention

Selection of the graphic material

A documentary analysis was conducted on mental health graphic material through the Graphic Medicine (Graphic Medicine International Collective, 2025) and the Spanish Society of Graphic Medicine (SEMGRAF, 2025) websites.

The inclusion criteria for the graphic material were as follows: a) Topics: psychotic disorders, affective disorders, anxiety disorders, eating disorders, and neurodevelopmental disorders; b) Availability in Spanish; c) Peer-reviewed by health professionals; d) Adequacy of length, format and content.

The graphic novels selected were: *Las voces y el laberinto* (Ruiz Garzón & Bores, 2018), *Desmesura* (Bailiús, 2023), and *Manicomio* (Batalla & Xevídom, 2020) (psychotic disorders), *Cara o cruz* (Lubie, 2018) and *Fuerte y frágil* (Marín, 2023) (affective disorders), *Lo que más miedo te dé* (Abellán & Armand, 2022) and *Todas las personas que fui* (Casas, 2023) (anxiety disorders), *Comiendo con miedo* (Pavón Rymer-Rythen, 2022) and *¿Y a ti qué te ha pasado?* (Jordahl, 2024) (eating disorders), and *Habla María* (BEF, 2020) (neurodevelopmental disorders).

Use of graphic material

The intervention took place in the classroom. The intervention consisted of reading selected excerpts from the graphic novels based on the following themes: the onset of first symptoms, the initial contact with mental health services, hospitalization, relapse, and recovery. First the literary material was assigned randomly to each subgroup. Along with the graphic novel, a guide was provided with questions designed to encourage focused and reflective reading. The objective of this guide was to reflect on the thoughts or emotions resulting from the reading. Each participant read the graphic novel using the guide as support to structure and deepen their experience.

Variables

Sociodemographic variables

Age, sex, and previous experience with graphic novels were collected.

Usability of the graphic novels

The User Experience Questionnaire (UEQ) was used after the intervention (post-only). This questionnaire is designed to help people reflect on their feelings, impressions, and attitudes associated with the use of a product. It consists of six scales: Efficiency, Perspicuity, and Dependability (pragmatic dimension); Stimulation and Novelty (hedonic dimension); and Attractiveness. It presents 26 items that are evaluated on a scale ranging from - 3 to + 3, where - 3 indicates the most negative response, 0 a neutral response, and + 3 the most positive. The results are grouped around six main dimensions, organized into two broad categories: pragmatic quality (which encompasses aspects related to the usability and functionality of the resource) and hedonic quality (linked to the emotional, motivational, and aesthetic dimensions of the experience) (Schrepp, 2015). The measured scale means were set in relation to existing values from a benchmark data set by the UEQ authors. This data set contains data from + 20K persons from + 400 studies. Interpretation of the comparison to benchmark is as follows: Excellent (In the range of the 10% best results), Good (10% of results better, 75% of results worse); Above Average (25% of results better, 50% of results worse); Below average (50% of results better, 25% of results worse); and Bad (In the range

of the 25% worst results) (Schrepp et al., 2017, 2019). The Spanish version was used (Rauschenberger et al., 2012).

Content validity of the graphic novels

The content and format of each graphic novel was evaluated after the intervention (post-only) on a Likert scale (1 = Does not meet the criterion; 5 = High level of compliance with the criterion) (Escobar-Pérez & Cuervo-Martínez, 2008): a) Comprehensibility: It is presented in a way that the content is easily understood, without confusion or ambiguity; b) Adequacy: It is appropriately tailored to address the selected mental health problem; c) Sufficiency: It includes all essential information to adequately represent the chosen mental health issue; d) Clarity: It is easy to understand, without excessive complexity and using appropriate language; e) Coherence: The narrative and visual elements of the graphic novel remain logical and consistent throughout the story; f) Relevance: The content is directly and significantly linked to the mental health issue addressed; g) Format: The visual structure, typography, and layout of the text in the graphic novel are attractive and functional, making it easy to read and follow the plot.

Attitudes and responses toward graphic novels

Attitudes toward graphic novels before the intervention (pre-only): Participants' perceptions of learning effectiveness, empathy, and content retention when using graphic novels compared to traditional learning methods (e.g., lectures).

Positive and negative affect before and after the intervention (pre-post comparison): The extent to which participants experienced positive (fun, joy, optimism, confidence, gratitude, calm, wonder, happiness, etc.) and negative (stress, fear, irritability, guilt, shame, sadness, hatred, nervousness, shyness, etc.) emotions.

Motivation to learn about mental health before and after the intervention (pre-post comparison): The level of interest, engagement, and willingness of participants to learn about mental health.

Motivation to read mental health graphic novels before and after the intervention (pre-post comparison): The level of interest and willingness of participants to read mental health graphic novels.

Enjoyment of reading mental health graphic novels before and after the intervention (pre-post comparison): The degree to which participants found graphic novels enjoyable, engaging, and satisfactory.

Perception of graphic novels in mental health education after the intervention (post-only): Participants' understanding and conceptualization of graphic novels as educational resources in the context of mental health.

Willingness to use mental health graphic novels before and after the intervention (pre-post comparison): Participants willingness to borrow graphic novels from the Graphic Psychology section of the university

library.

Visual observations

The research team (seven researchers) observed behaviors that reflected the interest aroused by the comic, followed by a debriefing session in which impressions and observations were shared and discussed. The categories observed were: attention (concentration), emotions (facial or verbal expressions), interaction with the novels (touching, photographing, etc.), and interaction among students.

Data collection

Data was collected using a Data Collection Booklet, subsequently digitized and exported in .xlsx format. Data is publicly available in Mendeley data (Goodman-Casanova, 2025).

Analysis

Descriptive statistics were presented according to the distribution and nature of each variable (continuous: mean, standard deviation, and median; categorical: counts and percentages). Pre- and post-intervention variables were compared using the Wilcoxon w test. For this comparison the Bonferroni correction criterion was applied, which was calculated by dividing the significance level (.05) by the number of tests (5) ($p=.05/5=.01$). The significance level was set at $p<.01$. A narrative description was carried out for the visual observations.

Results

The sample consisted of 158 students who read, in subgroups, excerpts from 10 different graphic novels. Most were female students 126/158 (79.7%) and 1 non-binary participant (0.6%); the mean age of the students was 20.49 years (SD = 4.6). Regarding comic book reading habits (graphic novels, comics, or illustrations), 132/158 (84.2%) students indicated that they rarely or never read, 18/158 (11.4%) did so at least once a month, 5/158 (3.2%) at least once a week, and only one person read comics every day or almost every day.

Usability

The graphic novels showed a Good level of Attractiveness (mean = 1.82), an Above Average level of Pragmatic quality (mean = 1.68), and a Good level of Hedonic quality (mean = 1.75) (Fig. 1).

In comparison to the benchmark data, the graphic novels of this study scored as follows: Excellent: Perspicuity (mean = 2.012, SD = 0.919), Stimulation (mean = 1.713, SD = 1.133), and Novelty (mean = 1.790, SD = 1.190); Good: Attractiveness (mean = 1.82; SD = 1.062) and Efficiency (mean = 1.573, SD = 1.068); and Above Average: Dependability (mean = 1.461, SD = 0.808) (Fig. 2).

Content validity

The results obtained in relation to the content validity of the graphic novels reflect a high degree of compliance with most of the criteria evaluated, all of which were above the average value of the scale. Clarity was the highest-rated dimension (mean = 4.59, SD = 0.699), followed by Format (mean = 4.57, SD = 0.735), Relevance (mean = 4.56, SD = 0.662), and Coherence (mean = 4.51, SD = 0.702). On the other hand, the dimensions of Adequacy (mean = 4.48, SD = 0.656) and Comprehensibility (mean = 4.46, SD = 0.737) were ranked medium to high. Finally, Sufficiency was the lowest-scoring aspect (mean = 3.99, SD = 0.963), although it remained close to the high level.

Attitudes and responses toward graphic novels

Regarding prior attitudes of students toward graphic novels in comparison to lectures, lectures were only considered more useful for acquiring theoretical information, with 78.4% of combined ratings. In contrast, the use of graphic novels clearly outperformed the lecture in multiple dimensions, especially those related to personal, emotional, or empathic experience (Table 1).

Table 1
Prior attitudes toward graphic novels in comparison to lectures

Theoretical information acquisition	Much more a lecture, n (%)	A little more a lecture, n (%)	Both equally, n (%)	A little more a graphic novel, n (%)	Much more a graphic novel, n (%)
	50 (31.6)	73 (46.8%)	13 (8.2%)	11 (7%)	6 (3.8%)
Symptom recognition in real-life contexts	12 (7.6)	26 (16.5)	21 (13.3)	69 (43.7%)	27 (17.1%)
Real-world relevance of academic content	8 (5.1)	18 (11.4)	37 (23.4)	52 (32.9%)	36 (22.8%)
Understanding of daily life impacts	7 (4.4)	20 (12.7%)	28 (17.7%)	65 (41%)	35 (22.2%)
Development of empathy	7 (4.4)	7 (4.4%)	29 (18.4%)	56 (35.4%)	56 (35.4%)
Academic engagement	12 (7.6%)	20 (12.7%)	42 (26.6%)	61 (38.6%)	20 (12.7%)
Long-term recall	5 (3.2%)	8 (5.1%)	24 (15.2%)	56 (35.4%)	62 (39.2%)

A comparative analysis before and after the intervention is presented for changes in affect, motivation and enjoyment (Table 2). No statistically significant changes were found in positive affect (3.26 vs. 3.32, $p = .415$) nor negative affect (2.18 vs. 2.30, $p = .128$). Significant changes were found in motivation to learn about mental health (4.45 vs. 4.57, $p = .011$), motivation to read mental health graphic novels (3.08 vs. 3.90, $p < .001$), and enjoyment of reading mental health graphic novels (3.14 vs. 3.89, $p = .001$).

Table 2
Variable scores before and after the intervention, and p values.

Variable	Scores before the intervention, mean (SD)	Scores after the intervention, mean (SD)	p
Positive affect	3.26 (0.890)	3.32 (1.066)	.415
Negative affect	2.18 (1.018)	2.30 (1.143)	.128
Motivation to learn about mental health	4.45 (0.634)	4.57 (0.676)	.011*
Motivation to read mental health graphic novels	3.08 (1.18)	3.90 (1.02)	.001*
Enjoyment of reading mental health graphic novels	3.14 (1.28)	3.89 (1.07)	.001*
The correlation coefficients meet the Bonferroni criterion for significance ($p=.05/5 = 0.01$).			

After the intervention, 120/158 students (77.4%) stated that they had changed their perception regarding the use of graphic novels as educational tools to address mental health-related content.

Regarding the willingness to borrow graphic novels from the Graphic Psychology section of the university library, the data revealed that only 6/158 students (3.8%) had ever borrowed one before the intervention. It is noteworthy that, after reading the graphic novels, 136/158 (87.2%) expressed their intention to consult a copy of this section.

Visual observations

The observations collected were shared among the research team and a consensus-based summary was provided. When the copies of the graphic novels were distributed, they were generally well received by the students, although some emotional reactions of surprise or disbelief, for example, were observed. Upon opening them, some students explored the novels by touching them, or examining them in detail, which highlights the motivational value of the sensory experience provided by the physical format. Shortly after beginning the intervention, the students seemed focused and immersed in the reading, demonstrating engagement with the stories. When they spoke to each other, it was to comment on some aspect of the comic. Interestingly, when finishing reading the excerpts, many students opened the graphic novels again to read the rest of the content and some even photographed pages with their cellphones.

Discussion

The findings in this study show the potential usability of graphic medicine among psychology students as an educational tool for addressing mental health-related content. Moreover, the results suggest impacts in motivation to learn about mental health, motivation to read mental health–focused graphic novels, and enjoyment in doing so.

The usability results indicate that mental health–focused graphic novels were positively received by psychology students. In the context of psychology education, high Perspicuity is especially relevant, as it facilitates the understanding of complex mental health concepts without oversimplification, potentially supporting more accurate conceptual frameworks. The high Stimulation and Novelty scores may reflect the alignment of this format with Generation Z learning preferences, which favor creative, visually rich, and interactive resources over purely textual materials (Shorey et al., 2021). Positive ratings in Attractiveness and Efficiency further suggest that the format not only captures students’ attention but also supports effective learning processes in a consistent manner. However, the comparatively lower score in Dependability may indicate variability in how students perceive the reliability or consistency of this resource, possibly influenced by differences in prior exposure to graphic novels or by the subjectivity inherent in interpreting visual narratives. This could suggest the need for structured guidance or integration with other teaching methods to ensure consistent learning outcomes. Compared to previous user-experience studies, these results position graphic novels as a promising medium for promoting sustained engagement and facilitating the integration of theoretical knowledge with real-world mental health contexts in the training of future psychologists (Schrepp et al., 2017).

The content validity results reflect a high degree of compliance with most of the evaluated criteria. Clarity emerged as the highest-rated dimension, indicating that students found the graphic novels easy to understand. The Format also obtained a high score, reflecting positive perceptions of the visual layout and design. Relevance and Coherence were similarly well rated, suggesting that the topics were considered important and that the content was presented logically and cohesively. These findings match previous studies reporting that graphic novels help students engage in critical reflection and with challenging theoretical concepts, supporting the view that this medium can facilitate the learning of complex material across different health disciplines (Williams et al., 2024).

When comparing traditional and innovative learning methods, the findings of this study underscore the complementary nature of these two formats: while lectures remain effective for the structured transmission of theoretical frameworks, graphic novels appear to excel in developing empathy through relatable narratives and visual storytelling. The superiority of graphic novels in this dimension aligns with previous research highlighting the role of narrative and visual media in fostering emotional engagement, perspective-taking, and the development of human-centered professional skills (Consorti et al., 2023; Noe & Levin, 2020). These results suggest that integrating graphic novels alongside traditional lectures could offer a more balanced pedagogical approach, combining the strengths of each method to address both cognitive and affective learning objectives.

No statistically significant changes were observed in either positive or negative affect following the intervention, although slight increases were noted in both dimensions. The modest rise in positive affect may indicate that the graphic novels were perceived as engaging and enjoyable, even if the change was not large enough to reach statistical significance. Interestingly, the increase in negative affect could be related to the emotionally charged nature of the narratives, which often depicted the challenges faced by individuals with mental health conditions. This response may reflect an empathetic engagement with the

characters' experiences, whereby students momentarily share the distress or struggle portrayed in the stories. Such an effect, while not the primary aim of the intervention, could be pedagogically relevant in fostering emotional awareness and sensitivity—competencies that are essential for future clinical practice in psychology. Similarly, previous research has shown that reading a graphic novel significantly increased negative affect in psychology students, however, this change was independent of the increase in motivation, as no correlation was found between the two variables (García Borrego & Castilla-Ortega, 2025).

The results in motivation and enjoyment suggest that exposure to the narratives and visual elements of the novels, not only enhanced interest in the specific educational content, but also increased receptiveness toward the medium itself. This dual effect is particularly relevant in psychology education, as it indicates that graphic novels can serve both as a catalyst for topic-specific engagement and as a sustainable learning resource that students are more willing to revisit. These findings align with previous research which has shown that reading a graphic novel significantly increased motivation in psychology students to learn about health themes compared to a lecture (García Borrego & Castilla-Ortega, 2025). The rise in enjoyment further reinforces the potential of graphic novels to create positive associations with learning, a factor that has been linked in prior research in healthcare professional education to improved retention, deeper processing of content, and greater long-term engagement with complex subject matter (Anderson et al., 2016; Consorti et al., 2023; Lesińska-Sawicka, 2023; Noe & Levin, 2020; Williams et al., 2024).

After the intervention, most students reported a change in their perception of graphic novels as educational tools for addressing mental health–related content. This shift suggests that direct exposure to the medium may challenge preconceived notions about its academic value. The marked increase in students' willingness to borrow graphic novels from the university library further reinforces this attitudinal change, indicating a move from passive acceptance to active interest in engaging with the resource. Such behavioral intention is relevant from an educational perspective, as it reflects not only receptiveness but also the likelihood of continued, self-directed use beyond the scope of the intervention. This finding aligns with literature on educational innovation, which highlights that positive first-hand experiences can be pivotal in reducing skepticism toward unconventional learning tools and fostering their long-term adoption (Shorey et al., 2021).

Overall, our findings are consistent with previous research on graphic medicine in healthcare professional education. Evidence from similar disciplines indicates that graphic medicine can enhance observational skills, deepen subject knowledge, support the formation of professional identity, and promote more empathic and holistic approaches to person-centered care (Anderson et al., 2016; Noe & Levin, 2020). A recent scoping review with medical students reported that this format can support the achievement of cognitive learning objectives while also nurturing soft skills and professionalism (Consorti et al., 2023). In the context of nursing education, its use has been associated with knowledge gains (Lesińska-Sawicka, 2023) and with fostering critical reflection on complex theoretical content (Williams et al., 2024). These parallels suggest that the benefits identified in our sample of psychology

students are part of a broader trend across health professions education, while also extending the evidence base to a population in which this approach had not been previously explored.

This study presents several limitations that should be considered when interpreting the results. First, the intervention consisted of a single and short exposure to individual excerpts which may have influenced the overall understanding of the narrative message and the emotional connection with the characters. Future studies should explore longer-term and repeated use of entire graphic novels to ensure deeper integration into the curriculum and avoid the risk that students perceive them as peripheral or merely supplementary resources. Another relevant limitation is the potential influence of social desirability bias in the students' responses, especially since the study was conducted within an assessable subject. Furthermore, it remains unclear whether the motivating effects observed are short-lived or sustained over time, highlighting the need for longitudinal follow-up. Finally, future research should compare the effectiveness of graphic novels with other educational materials or pedagogical strategies to determine their relative impact on both cognitive and affective learning outcomes.

Conclusions

The findings of this study highlight the potential of mental health-focused graphic novels as innovative resources for training future psychologists fostering more creative, empathetic, and adaptive learning to contemporary changes, and preparing professionals for a more humane and change-adapted psychology. While lectures continue to be recognized as an effective source for conveying theoretical content, the use of graphic novels has proven particularly useful in fostering student understanding of real-life experiences related to mental health, empathy, and motivation.

Declarations

Ethics approval and consent to participate

The protocol was approved by the Málaga Experimentation Ethics Committee (CEUMA) (96-2022-H) and ethical guidelines were followed. Students were informed via the Information Sheet and Informed consent was obtained prior to participation in the study.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

JMGC, ACEA, IPT, ECO: Made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; JMGC, ERSI, JGP, ECO: Drafted the work or revised it critically for important intellectual content; JMGC, ACEA, IPT, ERSI, JGP, ECO: Approved the version to be published; and JMGC, ACEA, IPT, ERSI, JGP, ECO: Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Data Availability

Goodman Casanova, Jessica Marian (2026), "Exploring the usability of graphic medicine as an educational tool among psychology students", Mendeley Data, V2, doi: 10.17632/s34dh5nwp7.2

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Figures

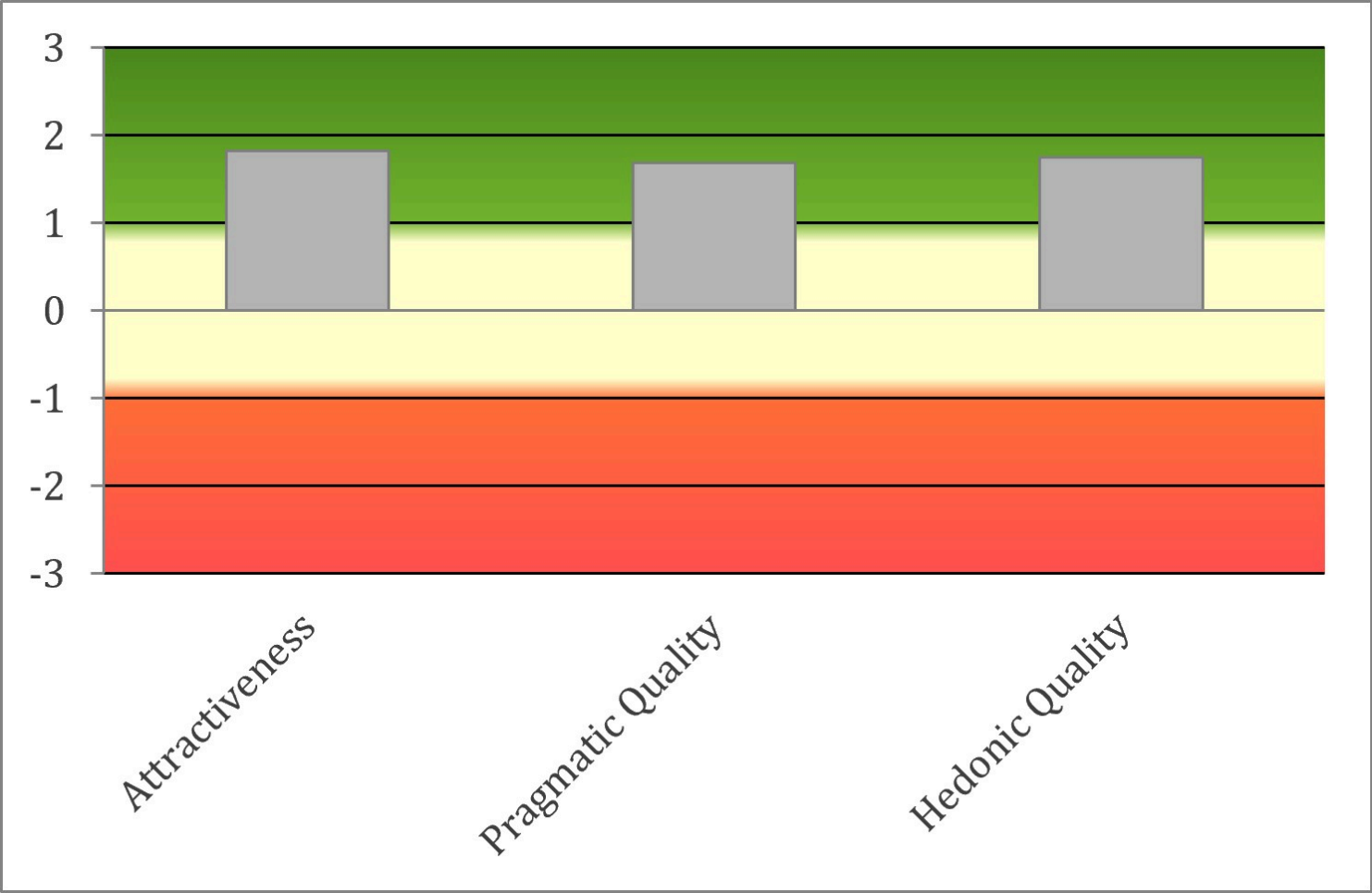


Figure 1

Means of the Attractiveness, Pragmatic and Hedonic Qualities.

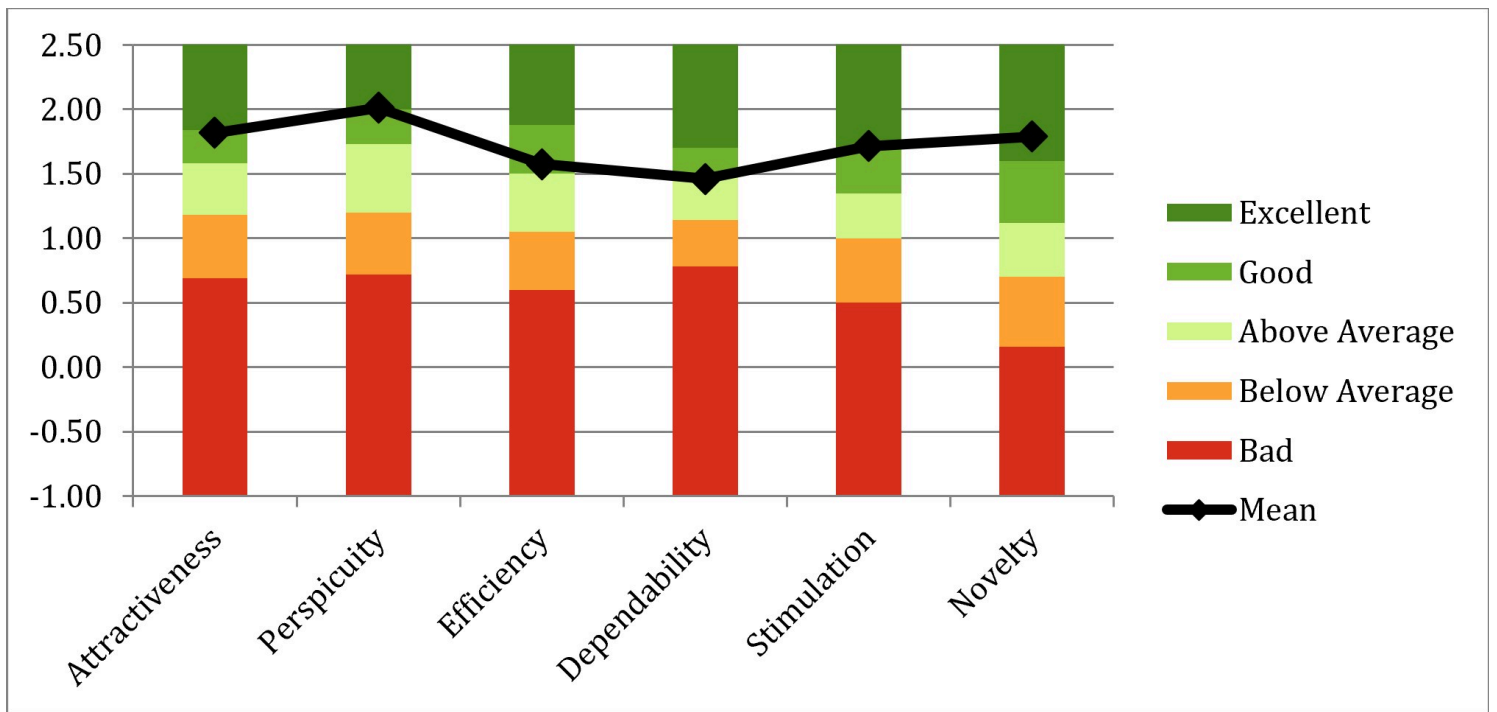


Figure 2

Comparison to benchmark and interpretations.