

The Devil in the Design Details:

Assessing the Impact of Educational Application Design on Teenagers' Mental Health

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Abstract

Technology is rapidly integrating with society and education. Mobile devices are at the forefront of technology use. At the same time, mental health issues are rising in adolescents. The use of mobile devices for learning purposes is touted to increase engagement and accessibility but inevitably affects adolescents' mental health. This review examines the various relationships between the design of educational mobile applications and adolescent (teenager) mental health. The purpose of the research is to investigate educational application design elements that impact teenagers' mental health. This review analyzes recent studies (2014-2024) from the Memorial University Library and Google Scholar databases. The research highlights which design elements may be detrimental to student mental health and which can improve or support mental health. Findings indicate that design elements intended to increase engagement may result in sleep disturbances, musculoskeletal pain, and increased anxiety. Positive results are shown in applications that promote mental health awareness and agency to teenagers. This review emphasizes the complexity of mental health and the importance of informed technology integration that puts student health at the forefront.

Keywords: emotional design, application design, adolescent mental health, educational applications, literature review

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Introduction

Context

Digital technologies have become increasingly integrated into society. It is hard to say if technology influences society or vice versa; there is a bidirectional relationship between society and technology (Barbour, 1993, as cited in Moore & Ellsworth, 2014), though it is evident that society adopts technologies before fully understanding the consequences.

Societal norms around technology use also influence education. “[T]he idea that technology enhances learning is an accepted orthodoxy, a common sense view of teaching and learning, and to resist this view seems to fly in the face of rationality” (Goodchild & Speed, 2019, p. 950). The quick adoption of technology has led to a rise in mobile device use in learning. Mobile learning uses educational applications to assist traditional classroom teaching (Lee & Xiong, 2022) and personal learning outside the classroom.

Teenagers spend many of their formative years learning in the education system. Teenagers are the group that uses mobile devices the most, and there is also a rise in mental health issues in the age group (Haidt & Allen, 2020). While many factors affect mental health, teenagers are in a developmental stage, and researchers correlate the inability to limit device use with mental health problems (Poetar et al., 2024). With the addition of educational applications in class and for personal learning, students’ ability to limit device use may be more challenging.

While there are correlations between device usage and mental health issues, specific aspects of devices and applications affect those correlations. The relationship between device use

and mental health is a “triple-edged sword” (Hollis et al., 2020), involving positive aspects, negative aspects, and nuanced effects depending on usage. The design elements and intentions of applications may determine their influence on users’ mental health. While educational applications have a beneficial use case, they may still contribute to the effects that digital devices on students’ mental health. Thus, the design of educational applications may affect the outcomes related to students' well-being.

Problem

When applications are designed to address mental health, they can have a positive impact (Fausett et al., 2020); however, with some intentional design elements, such as gamification, have unintended mental health effects (Abassi & Awais, 2022). There are also overlooked effects, including exposure to artificial blue light from digital devices (Baeza Moyano et al., 2020; Bauer et al., 2018; Campbell et al., 2023; Perrault et al., 2019). Additionally, emotional design may be used to induce an emotional response to learning with unknown outcomes (Kumar et al., 2018).

Educational applications are focused on specific learning goals, which often overlook the human element, leading to unintended effects on the mental well-being of learners. Thus, examining design elements in the context of educational applications is crucial to investigating the impact on students’ mental health and making healthier technology choices.

Purpose

The purpose of this literature review is to explore the features and oversights involved in educational application design that affect the mental health of teenage learners.

Research Questions

This review aims to investigate: RQ1) What is the impact of educational application design on the mental health of teenage learners? RQ2) Which design elements adversely affect teenage learners? RQ3) How can educational applications be designed to improve student mental health?

Definitions of Terms and Rationale

To ensure clarity throughout this paper, the following terms are defined. These definitions provide the context for understanding the claims and results of this literature review.

Cognitive Load

“Cognitive load” is defined as the “load induced by learning tasks [that] affect student’s ability to process new information and to construct knowledge in long-term memory” (Sweller et al., 2019, p. 261-262). For this review, “Cognitive load” refers mainly to the demands imposed on the cognitive system. As an instructional design theory, the cognitive load theory pertains to technology-based instruction in determining its effectiveness (Sweller, 2020). Therefore, cognitive load is essential to consider when reviewing the design of educational applications.

Mental Health

“Mental health” is defined as the well-being of an individual’s mind and associated issues, such as anxiety, stress, and cognitive load. In addition, “mental health” refers to the building blocks of mental health: mood, social communication, and sleep (Haidt & Allen, 2020). Mental health is a complex issue that cannot be distilled into “good” or “bad” aspects (Hollis et al., 2020), so an all-encompassing definition is explored in this review.

Educational Application

An “Educational Application” (EDAPP) is defined as the software used by students to assist traditional classroom learning (Lee & Xiong, 2022). EDAPPs can be standalone applications or applications that help students interface with other educational technologies and e-learning multimedia, including web apps. For this review, EDAPPs will be assumed to be accessible via computer screens and mobile devices.

Design

“Design” is defined as a “planning and execution process to develop something in order to solve a specific problem” (Smith & Ragan, 2005, as cited in Li et al., 2020). In the context of EDAPPs and this review, design refers to the planning and implementing features in EDAPPs to achieve a learning outcome.

Emotional Design

“Emotional design” is defined as the “planning and implementation of visual elements in learning material that affect learners’ emotions” (Um et al., 2012, as cited in Li et al., 2020, p. 2). The visual elements of emotional design include aesthetics (Kumar et al., 2018), human faces (Beege et al., 2018), and usability (Li et al., 2020). If emotional design affects learners’ emotions, then it may be essential to consider the design of EDAPPs concerning students’ mental health.

Teenagers

“Teenagers” are defined as students who are aged 13-19. Much research focuses on “adolescence,” but the term is often used synonymously with “teenager.” This review will focus

on the teenage years of adolescence, high schoolers, and the early years of university students. The focus on the teenage years of adolescence may target the “middle ground” of brain development, possibly avoiding outliers on the ends of the adolescent age spectrum. The teenage years are a sensitive period of growth with a high response to stress and cognitive training (Fuhrmann et al., 2015), which makes “the brain [...] especially susceptible and vulnerable to environmental input and to the formation of irreversible pathways and networks” (Poetar, 2024, p. 208). Thus, the effects of digital devices and application design may particularly impact teenagers' mental health.

Method

This literature review aims to synthesize and analyze research regarding the impact of EDAPP design on the mental health of teenagers. Through analysis of the research findings, this study aims to explore which design elements affect teenagers' mental health and how the design of educational applications may improve student mental health.

This review includes qualitative and quantitative studies on EDAPP design elements and adolescents' mental health. Only studies published between 2014 and 2024 are considered to provide possible answers to the research questions, and data relating to students outside of their teenage years is not relied upon; studies that did not include a significant focus on teenaged participants were rejected.

Using the Memorial University Library and Google Scholar databases, studies were filtered by the following search terms: “educational applications AND mental health,” “emotional design AND education,” “mobile applications AND adolescent mental health,” “educational applications AND design,” “gamification AND mental health,” “blue light AND emotion AND education,” “cognitive load AND educational technology.” These studies were

analyzed for relevance and were collected if the data related to adolescents, emotional states and mental health, and design features used in EDAPPs.

Relevant studies were sorted into categories: adverse mental health effects, positive mental health effects, and overlooked mental health effects. Each study was analyzed according to the categories, and the references were stored with annotations in a document. The studies were further synthesized and categorized according to intentional and unintentional design elements. Data relating to particular mental health outcomes were of specific interest and constituted most of the critical review.

Critical Review of the Literature

The Impact of Intentional EDAPP Design Elements on Teenager's Mental Health

Intentional design elements are of high consideration for EDAPPs. These design elements are purposefully included to elicit a particular response in students, though their mental health effects may vary. The following EDAPP design elements are frequently used to directly address student behaviours or mental states for learning.

Gamification

Gamification is a design feature that uses game elements: “points, badge, feedback, level, rewards, challenges, etc.” (Saleem et al., 2020), which have been used in e-learning through EDAPPs. Saleem et al. (2020) conducted a qualitative study of the literature between 2015 and 2020 that included articles related to “gamification” and “e-learning.” While the studies did not pertain to teenagers exclusively, the authors found numerous studies indicating that gamification has positively affected student motivation and engagement in learning outcomes in e-learning.

When used correctly, gamification can positively impact student mental health by creating a “fun spirit to academic activities” (Saleem et al. 2020, p. 153).

In another literature review by dos Santos et al. (2023), researchers examined intervention studies using gamification in health education for adolescent students (ages 10 to 19). dos Santos et al. (2023) imply that gamification through EDAPPs can produce positive cognitive, social and emotional results. However, it is essential to gain a deeper understanding of the psychological effects of gamification. In terms of mental health effects, dos Santos et al. (2023) found that “gamification brings out emotions in the players, such as pride, joy, optimism, curiosity, and even frustration” (p. 6). Though gamification can increase engagement, the findings imply adverse effects as well.

While studies have often overlooked the adverse effects of gamification, some authors have begun to fill the gap in the literature. Edwards (2022) conducted a literature review of peer-reviewed studies between 2012 and 2022 related to gamification and second language learning anxiety. Some studies in the review address teenage populations, though the review does not specify the age criteria. Edwards (2022) concludes that gamified challenges and competition, including points and leaderboards, did not affect anxiety positively; thus, educators should focus on cooperative and supportive learning.

Andrade et al. (2016) reviewed existing literature and frameworks to conduct a qualitative analysis of the harmful effects of gamification. The authors conclude that gamified elements in EDAPPs designed to keep students in deep concentration can lead to addiction and dependence, and thus usage should be monitored. Abbasi and Awais (2020) followed Andrade et al.’s (2016) theories and conducted a study to analyze which gamification elements caused addiction. The researchers conducted interviews with psychologists and surveys of smartphone

users, of which only 11% were teenagers. However, Abbasi and Awais (202) conclude that age is not a factor in smartphone addiction and that adolescents may be even more susceptible. The authors also conclude that the most addictive game elements are scrolling, tapping and stories, and pop-up notifications. Controlling these elements seems to be vital in addressing the issues.

These studies show that some aspects of gamification impact teenagers' mental health differently and choosing gamification elements is a crucial consideration in EDAPP design.

Emotional Design

Emotional design in EDAPPs intentionally tries to affect students' emotional states to produce a desired outcome. The suggested thought is that emotional design could influence mental health.

Kumar et al. (2018) conducted a study with 95 engineering students, of which 68.4% were aged 18-20. The study used emotional design in the graphical user interface (colours, fonts, and images) of a computer-based EDAPP. The researchers conclude that "negative" design aesthetics ("sad colours" and unattractive fonts) had positive learning effects on engineering students, indicating that specific aesthetics provide benefits in fields of study. Thus, EDAPPs must be aware of the target audience, as the impact of the design depends on the user.

Li et al. (2020) conducted a quantitative study to examine emotional design (colour and anthropomorphism) and its impact on the emotions of college freshmen aged 16-25 (average 19). Using neutral (control) and "positively" charged (face-like shapes and warm colours) multimedia lessons, the researchers examined student emotions through learning tests and physiological measurements. Li et al. (2020) agree with Kumar et al. (2018) that emotional design affects learning outcomes. While emotional design does not evoke emotion in students, Li et al. (2020)

state that emotional design may still affect students' moods, as implied by the change in learning outcomes.

Shangguan et al. (2020) also tested colour and anthropomorphic emotional design on 124 teenage middle school students using a computer-based EDAPP. The findings agree with Kumar et al.'s (2018) findings that colour impacts student learning. In Shangguan et al. (2020), however, "positive" colours and anthropomorphism positively affected student learning outcomes. While emotional design can improve learning outcomes, the researchers also conclude that it increases the cognitive load, depleting the learner's cognitive resources. However, when testing the direct impact of emotional design on improving student emotions, Shangguan et al. (2020) found no conclusive evidence. Shangguan et al.'s (2020) findings also show that emotional design affects students' mental health depending on the details of the target audience.

In a study focused on 165 German high-school teenagers, Beege et al. (2018) examined the effect of positively charged (smiling and expressiveness) multimedia content via e-learning on student mood and learning outcomes. The researchers investigated the emotional impact and mental load. Beege et al. (2018) indicate that the emotional design of multimedia did not significantly affect students' moods; however, in contrast to Shangguan et al. (2020), the cognitive load of high-school teenagers may be reduced when content is positively charged. Still, Beege et al. (2018) conclude that students' moods congruent to the emotion design will lead to better learning outcomes.

The findings of these studies indicate that while emotional design has an impact on teenagers' mental health, the effect is nuanced. Therefore, designing EDAPPs with emotional design elements requires careful consideration of the target users.

Push Notifications

Push notifications are a design element in EDAPPs that notify users of an event or remind them to check the application. Used correctly, notifications can be helpful reminders for students to perform specific actions. In a study involving students aged 18-24, Pham et al. (2016) examined the effects of reminder notifications in EDAPPs on learners. The researchers found that notifications increased engagement with EDAPPs; however, too frequent notifications can negatively impact users' mental states by annoying or angering them. Pham et al. (2016) conclude that proper design of notifications is vital for the beneficial use of EDAPPs.

Because of the many push notifications one can receive on a device, the channel and origin of notifications affect users differently. Mihci and Ozdener Donmez (2017) conducted a quasi-experimental study of the effect of learning platform notifications on first-year university students. The experiment compared notifications through EDAPP platforms versus SMS text messages. The researchers note that the goal of notifications is to get students to engage with the learning platform and that the perceived urgency of a notification increases engagement. The researchers found that notifications pushed through less busy channels (i.e. SMS) effectively increased student engagement. However, the urgency to respond could also be associated with anxiety. Mihci and Ozdender Donmez (2017) also note that notifications can evoke shyness when students are expected to respond publicly through social networking sites.

Push notifications have been shown to elicit students to respond to EDAPPs, but the frequency and action demanded by the notifications will determine the effect on student mental health.

Mental Health-Focused EDAPPs

EDAPP design includes the intended purpose and content delivered through the application. EDAPPs can be designed to address or teach about mental health issues and strategies specifically. These mental health EDAPPs or mental health smartphone applications (MHSA) use the design features mentioned above to encourage users to engage in mental health activities through the applications.

Fausett et al. (2020) conducted a systematic literature review on adolescent MHSA design. The review identified key themes and contributions regarding smartphones and mental health in the PubMed and PsycInfo databases. Fausett et al. (2020) found numerous design themes positively impacting adolescent mental health via MHSA; however, no themes focused on the adverse effects.

Push Notifications in MHSA. In congruence with Pham et al. (2016), Fausett et al. (2020) found that giving users control over notification frequency positively affected learners engaging in mental health activities.

In a qualitative study by Naccache et al. (2021), the researchers interviewed eight female teenagers who tested an MHSA and found that the frequency of notifications was also important. While notifications could improve long-term commitment, participants were worried that the notification would remind them of their disorders leading to shame and reduction in mental health.

Emotional Design in MHSA. Other personalization features, such as colour, emphasized the importance of personalized emotional design. Duguid et al. (2022) conducted a mixed-method study involving a quantitative survey of adolescents using a music-focused MHSA. The researchers agree with Fausett et al. (2020) that customization of colour design affects

application usability. The results also suggest that young people are enthusiastic about music as a tool for improving well-being.

Gamification in MHSA. Fausett et al. (2020) found that gamification increased MHSA engagement, positively impacting mental health practices. Naccache et al. (2021) also found that gamification elements (trophies) motivated some participants; however, some participants felt that the trophies would lead to obsessive behaviour or cause unnecessary pressure, thus negatively affecting their mental health.

Li et al. (2020) surveyed 66 adolescents (ages 12-17) about gamification in an MHSA and found gamified elements to have adverse effects. While the younger participants thought of gamification as “fun,” the older participants felt that it trivialized the mental health aspect.

Privacy in MHSA. Numerous barriers prevent teenagers from accessing mental health services. While MHSAs open new pathways for receiving help, Fausett et al. (2020) determined that respecting privacy in MHSAs increased the likelihood of users engaging with the applications. Naccache et al. (2021) agree that confidentiality of information and the use of MHSA are vital for teenagers to avoid embarrassment and stigma.

While in-application privacy is essential, sharing mental health concerns with trusted individuals can be a goal of MHSAs. Birrell et al. (2022) conducted a quantitative analysis via a survey of 23 teenage students who beta-tested an MHSA designed to educate them on supporting peers with mental health issues. The researchers also noted that privacy was a vital component of the application design, and participants rejected the idea of a social media component. However, findings also show that education through the MHSA helped to empower teenagers to talk about mental health with their friends openly and support them in seeking further help.

In a randomized controlled trial by O'Dea et al. (2020), the researchers surveyed 193 adolescents on the effectiveness of a relationship-focused MHSA. The results showed that the MHSA fostered a significant increase in teenagers' willingness to seek professional help for mental health issues, leading to improved well-being.

Treating Mental Health with MHSA. Concerning mental health treatments, studies suggest that MHSAs can impact behaviours leading to mental health improvements. Still, there is little clinical evidence showing that MHSAs can affect mental health issues directly.

Badesha et al. (2023) utilized a mixed-methods single-case experiment to test the effects of cognitive behaviour therapy (CBT) on five female teenagers. The researchers concluded that while the MHSA promoted CBT behaviours in the participants, there was no effect on participants' negative thinking or well-being.

O'Dea et al. (2020) concur that their MHSA encouraged help-seeking behaviour, but there was no evidence to suggest that the MHSA helped to reduce depressive symptoms in participants.

In a more extensive study by Werner-Seidler et al. (2019), researchers conducted a single-arm pre-post experiment examining 50 adolescents aged 12-16 suffering from sleep difficulties. Werner-Seidler et al. (2019) determined that their sleep-focused MHSA helped adolescents with insomnia through CBT. The MHSA also led to a reduction in depression symptoms as a secondary result of treating adolescent insomnia symptoms.

Studies indicate that MHSA may be beneficial in delivering mental health education to teenagers and that they can influence behaviours that may lead to improving mental health. When used correctly, design features of the MHSAs, such as gamification, push notifications, and emotional design, can increase user engagement. However, MHSAs are not a way of

replacing humans; instead, they can be a means to enhance connectedness and support the therapies of trained professionals (Bantjes, 2022).

The Impact of Unintended EDAPP Design Elements on Teenager's Mental Health

EDAPPs are intended for educational purposes and are designed with increased engagement and learning as a primary outcome. While intentional design elements can affect students' moods and motivations towards learning, by demanding or increasing engagement with EDAPPs, students are necessarily exposed to unintended or overlooked design elements, such as blue light and musculoskeletal effects.

Blue Light Exposure

Blue light exposure is a byproduct of using digital devices, which may be overlooked when designing EDAPPs; application designers focus on increasing application usage without considering the overall effects of blue light exposure from device screens.

A critical review study by Baeza Moyano et al. (2020) examined scientific literature and European regulatory documents pertaining to the effects of artificial lighting on adolescents. The review states that adolescents are particularly susceptible to the effects of lighting due to their developing biological clocks and extending exposure to devices. The researchers suggest that exposure to artificial light from devices or classroom lighting can disrupt mood and circadian rhythms, leading to other emotional disorders. However, Baeza Moyano et al. (2020) also recommend blue light exposure in the morning to increase mood and alertness.

Additional reviews of the literature by Bauer et al. (2018) and Campbell et al. (2023) attest to the increased risk of circadian disruption in teenagers due to blue light exposure at night, leading mental health problems due to sleep disruption.

Figueiro and Overington (2016) carried out a single-arm study testing the effects of self-luminous devices (smartphones and computers) on melatonin levels in 20 teenagers aged 15-17. The findings concur that self-luminous devices producing blue light suppress melatonin production in teenagers, and that adolescents may be more susceptible to the risks of blue light exposure. By default, students exposed to prolonged use of devices through EDAPPs may experience sleep disturbance. However, Figueiro and Overington (2016) found that the negative effects of blue light exposure from self-luminous devices can be prevented by wearing orange-tinted glasses three hours before sleep.

In a study by Perrault et al. (2019), researchers examined sleep habits of over 500 adolescents using sleep monitoring and questionnaires. The study tested the effects of screentime at night on different ages of adolescents. The researchers found that teenaged adolescents (14-19) are particularly sensitive to sleep disturbances as they require increased sleep duration. The study recommends reduced screentime at night to improve sleep quality, and daytime vigilance.

While blue light exposure from prolonged EDAPP usage does not show immediate detrimental effects on the mental health of teenagers, there is evidence that sleep disturbance from nighttime device usage leads to poor mental health. Thus, timing and duration of the use of EDAPPs is worth considering in design.

Musculoskeletal Effects

When EDAPPs are designed for prolonged, repetitive actions, they can affect the physical condition of users, which may lead to mental difficulties. Because of the form factor of digital devices, EDAPPs are confined to specific sizes and actions, forcing users into certain postures. Prolonged use of devices, even in educational situations can lead to musculoskeletal pain.

Hanphitakphong et al. (2021) did a quasi-experimental study involving 44 adolescent (average

age 14) smartphone users. The study examined postures of participants during extending gaming sessions. While smartphone gaming does not equate to EDAPP usage, overall smartphone usage for prolonged periods of 20 minutes or more were found to produce awkward postures and muscle fatigue especially in the neck. Thus, the researchers suggest limiting smartphone use for adolescents. However, no evidence is provided to suggest musculoskeletal impacts on mental health.

In a comprehensive system review of 250 studies from the year 2010-2021, Priya and Subramaniyam (2022) examined the associations between prolonged smartphone use and fatigue. The researchers found that increased smartphone use can lead to a variety of musculoskeletal disorders, and that adolescents are more susceptible to smartphone issues due to addictive tendencies. Still, Priya and Subramaniyam (2022) suggest no direct link between musculoskeletal issues and mental health, and that more research is needed to examine mental fatigue caused by device use.

Although there are few articles concluding that musculoskeletal issues directly affect teenagers' mental health, "[musculoskeletal pain] is considered multifactorial, having physical, psychological, and social aspects" (Akulwar-Tajane et al., 2021 & Al Omar, 2021, as cited in Salameh et al., 2022, p. 530). Thus, considering discomforts associate with prolonged device usage is notable in the design of EDAPPs.

Limitations and Further Research

Limitations

The results in this review depend on methodological constraints and data sample limitations. Although multiple search terms and concepts are included, the research topics are

confined to the ideas presented in this review. Other aspects of EDAPP design may have been overlooked in this context. Few studies address EDAPP design explicitly, so some generalized connections are made between smartphone application use and EDAPP use.

Further generalizations are made, as many studies are limited to specific populations. More diverse studies may be needed, as studies focus on certain ethnicities or school subjects. Some studies had small sample sizes, or the target ages for the review were only a portion of the total participants involved in the studies.

Further Research

The topic of mental health is difficult to study because of the challenges in controlling other factors that contribute to mental health issues. Future research with larger sample sizes and controlled studies will provide more conclusive evidence. Further research should include the impact of compounding effects of digital technologies concerning student mental health. Environmental pressures, accessibility, and lighting may work in tandem with EDAPPs, affecting their design and their impact on mental health. Additional research on differently-abled teenagers with visual, auditory, or mobility restraints would provide a broader picture of design necessities.

Discussion

This literature review demonstrates the complex relationship between EDAPP design and teenagers' mental health. It further highlights the "triple-edged sword" concept, which denotes that technology and mental health have positive, negative, and more nuanced correlations (Hollis et al., 2020). It is evident that while EDAPPs are purposed for learning, the effects they have on

mental health are dependent on the design. All the design elements discussed in this review have been shown to have polarizing effects on mental health, but effects, nonetheless.

Gamification and Mental Health

Gamification is a popular design element that improves engagement and entices students to participate in educational activities. This is true for general EDAPPs and for mental health-related EDAPPs. In both cases, however, studies show that there is a possibility for unwanted effects, such as competition anxiety and addictive behaviour (Edwards, 2022; Andrade et al., 2016), or trivialization of mental health issues (Li et al., 2022). These findings imply that gamification both positively and negatively impacts mental health and, therefore, must be implemented with careful design choices.

Emotional design and Mental Health

Emotional design, including colours, aesthetics, and anthropomorphic imagery, does not directly affect teenagers' moods (Beege et al., 2020; Li et al., 2020; Shangguan et al., 2020). However, colours affect how well the EDAPP is received (Duguid et al., 2022; Kumar et al., 2018). These findings did not have conclusive results on specific colours, but instead, they suggest that the effect depends on the user. The various colour findings imply that colour customization may be helpful for teenagers engaging with EDAPPs. Shangguan et al. (2020) suggest that anthropomorphic elements add to the cognitive load, and therefore, adding more content to processes detracts from the goals and puts extra stress on the user. Overall findings suggest that customizability of EDAPPs may improve user experience, though have little effect on mental health directly.

Push Notifications and Mental Health

Notifications increase engagement with EDAPPs but can also lead to annoyance (Pham et al., 2016) or anxiety (Mihci & Ozdener Donmez, 2017). Notifications may be helpful reminders, especially if they remind teenagers to practice mental health drills. However, notifications may be harmful if used to draw users into anxious situations. The implication is that notifications should be controllable by the user and used only for helpful purposes, not simply to draw attention.

MHSA and Mental Health

When it comes to designing EDAPPs specifically for mental health, the intention of the application is essential for mental health outcomes. The research suggests that there is little conclusive evidence showing that mental health EDAPPs improve symptoms of depression or well-being (Badesha et al., 2023, O'Dea et al., 2020). However, mental health EDAPPs have demonstrated a positive association with mental health awareness and behavioural changes (Badesha et al., 2023; Bantjes, 2022; Naccache et al., 2021; Werner-Seidler et al., 2019). MHSA that focus on improving sleep quality led to improved mental conditions in teenagers (Werner-Seidler et al., 2019). Thus, the design of mental health EDAPPs should empower teenagers to take action on their mental health but need not encourage users to spend more time with the application.

Blue Light and Mental Health

Blue light is a byproduct of EDAPP usage, and the screen-based devices. While EDAPPs are focused on learning outcomes and user engagement, prolonged blue light exposure is overlooked in design. It is conclusive that excessive blue light exposure will affect teenagers'

circadian rhythms and sleep quality, which is detrimental to mental health (Baeza Moyano et al., 2020; Bauer et al., 2018; Campbell et al., 2023; Perrault et al., 2019).

Musculoskeletal Effects and Mental Health

Musculoskeletal pain can arise from excessive mobile device usage (Hanphitakphong et al., 2021; Priya & Subramaniyam, 2022; Salameh et al., 2022). While the connections between musculoskeletal issues and mental health are ambiguous (Salameh et al., 2022), it is still advisable to consider how repetitive movements and prolonged use can be part of EDAPP design. Designers of EDAPPs should be mindful of the overall usage of mobile devices and consider the human on the other end.

Synthesis of Findings

Analysis of the research indicates that there is little evidence to support the idea that specific design features impact teenager's mental health positively or negatively in a ubiquitous way. However, albeit nuanced, the design features discussed in this review (gamification, emotional design, push notifications, blue light, form factor, mental health education) have some impact on teenagers' mental health. In addition to the nuanced and user-dependent effects, most intentional design features have been shown to increase user engagement with EDAPPs. However, the themes of the studies in the review imply that to improve teenagers' mental health, it is beneficial to design EDAPPs that encourage controlled (if not reduced) device usage in conjunction with content that addresses mental health awareness.

Conclusion

This review highlights the complex relationship between EDAPP design and teenagers' mental health, revealing challenging nuances, but also positive use cases. The impact of EDAPP design elements can be dependent on the user, implying a need for application customization and careful design.

RQ1: What is the impact of educational application design on the mental health of teenage learners?

The design elements of EDAPPs undoubtedly impact teenagers' mental health, but clear outcomes are difficult to determine. While numerous design features, such as gamification, emotional design and push notifications can impact students' interest and engagement with EDAPPs, it is too bold to say that design elements improve teenagers' mental health. On the contrary, many supposedly beneficial design features, such as gamification and notifications, can produce adverse effects, such as addiction and anxiety, leading to a reduction in mental health.

RQ2: Which design elements adversely affect teenage learners?

The adverse effects of EDAPPs can be found primarily in design elements that prolong the usage of mobile devices. Gamification and push notifications aim to encourage more involvement with applications. In addition to the nuanced effect of competition anxiety or unwanted reminders for specific mental health conditions, "engagement tactics" can lead to prolonged device use. Overuse of devices, especially smartphones, expose teenagers to inevitable externalities like artificial blue light and poor posture. Blue light is particularly harmful to teenagers at night, disturbing sleep, which leads to a decline in mental health. While the design

of an EDAPP is responsible for engagement with the device, the adverse effects are attributed to artificial blue light exposure.

RQ3: How can educational applications be designed to improve student mental health?

Key findings show that supporting teenagers' physical health (namely sleep) has a more beneficial effect on their mental health, than treatments provided through EDAPPs. However, mental health awareness education is critical for teenagers, and because of their frequent mobile device use, EDAPPs can be an appropriate channel for reaching the age group. Rather than promoting designs that increase MHSA use, the studies suggest that the answer to RQ3 lies in designs that influence teenagers' behaviors, such as CBT strategies, encouraging appropriate device usage, and fostering connections with trusted individuals.

Recommendations for EDAPP Developers

Developers of EDAPPs may have self-serving motivations (Goodchild & Speed, 2019) or overlook factors beyond the educational goals of the applications. When designing EDAPPs, it is recommended that elements of choice, control, and checks are included so that users can adjust the experience according to their mental health needs. EDAPPs should look beyond engagement as a design strategy; they should include health education and means for self-regulation, such as reminders to take a break and prompts for seeking out in-person connections. It is crucial to be reminded of the human on the other end of applications and that the goal should not be to extract knowledge from the student; instead, EDAPP design should prioritize the holistic health of the user over the delivery of content.

Recommendations for Educators

Educators may not directly influence the design of EDAPPs, but they have some control over the choice and implementation of technologies. When selecting EDAPPs, educators should also be advised of the potential harms and select applications with student mental health in mind. Mental health education and technology education can be taught in tandem. Where EDAPP choice is limited, educators can act as limiters of device use and remind students to take breaks and consider healthy choices.

Concluding Remarks

In education it is easy to hyperfocus on learning outcomes and dissemination of content knowledge. While EDAPPs are an effective tool for achieving learning goals, the effects of using these tools are not inherently “good” because they are designed for education. A gap in the knowledge still exists with regards to the mental health effects of EDAPP design on teenagers. This review has outlined some of the nuanced areas in EDAPP design that require more conclusive research. Until such a time that these design details are investigated further, it is advisable to scrutinize the available EDAPPs and implement them with individual well-being at the forefront.

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