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CINEMIMMUNOLOGY: THE POWER OF MOVIES IN IMMUNOLOGY EDUCATION

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Abstract:
Films can be a powerful educational tool, and this is known as cinema education. We at the College of Health Sciences and Pharmacy applied this universal learning method to the first and second-year pharmacy classes of basic immunology. Two workshops were introduced to the course, and the student's assessment pre- and post-workshop were analyzed. We used two Hollywood blockbuster movies, i.e., *The Incredibles 1*, *The Incredibles 2* and *The Boss Baby*, to enhance pharmacy students' grasp of basic immunology concepts. The students watched movies. The main plot was that the immune system is like a family with a dad, mom, girls, boys, and babies. Giving due credit to Brad Bird, the writer and director of *The Incredibles*. In his words (changed within brackets), he is quoted as follows: The characters of "*The dad is always expected in the family to be strong, so we made him (T cell) strong. The moms are always pulled in a million different directions, so we made her stretch like taffy (B cell). Teenagers, particularly teenage girls, are insecure and defensive, so we made her turn invisible and turn on shields (Antibody). Moreover, ten-year-old boys are hyperactive energy balls. Babies have unrealized potential. So, we made babies as cytokines*." Our results showed a significantly enhanced conceptual learning and long-term retention of immunological concepts. Even students with severe learning difficulties and disabilities who struggle with academic curriculum can often relate to film. It was also an example of associated learning using standard movies with a high-performance yield within a short period. We recommend the use of such strategies in immunology education. The commonly accepted education method is known as cinemeducation for imparting medical education, and when we used it to teach immunology, we called it cinemimmunology.

Keywords: cinema, education, immunology, innovative teaching methods, visual learning

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1. Introduction

Implementing innovative teaching methods is a crucial aspect of enhancing the quality of higher education (9, 16, 20, 25, 29). This is primarily achieved by fostering increased student engagement and promoting effective learning. Introducing innovative practices in education offers a mutually beneficial outcome for teachers and students, enhancing the quality of teaching, learning, and assessment processes (13, 14, 15, 24, 30). Implementing innovative strategies across diverse areas of higher education reinforces the academic environment and facilitates flexible learning. Modern educational tools, including smartphones, electronic content, tablets, laptops, video conferencing devices, smart boards, games, and social media, have become indispensable components of contemporary education, fostering enhanced interaction between teachers and students (19, 20, 21, 22, 23, 24, 25, 29, 30). These tools facilitate advanced learning and promote eco-friendly practices within the educational ecosystem.

Integrating artificial intelligence (AI) tools into education has significantly impacted teaching and learning across a range of disciplines (1). In a recent study, Graefen and Fazal (2023) investigated the potential of AI-powered platforms, such as ChatGPT, as tools for public health education (19). They identified the capacity of such platforms to facilitate personalized learning experiences and enhance student engagement as key benefits. The growth of social media platforms has provided new opportunities for distributing health-related information while presenting various challenges (38, 39). Graefen et al. (2023) have identified Instagram as a particularly effective platform for reaching a diverse audience, simplifying complex topics, and fostering health awareness (20, 23).

The application of film as an educational resource is widely acknowledged for its capacity to enhance student engagement and learning achievements (10). In addition to facilitating comprehension of complex theories and concepts, films also assist in maintaining students' interest in the subject matter, thereby representing a versatile resource for modern classrooms. Films permit students to explore diverse perspectives and engage in meaningful dialogue through active participation and group discussion. This participatory approach facilitates the development of critical thinking and interpersonal skills, which are essential for academic and professional advancement (10, 17). Furthermore, the introduction of film into pedagogical practices serves to mitigate the concerns that educators may have regarding communication with students who are highly proficient in the use of technology. Educators can successfully bridge generational and technological gaps by taking advantage of films' narrative and visual attributes, thereby creating an inclusive and dynamic learning environment (10). However, effectively utilizing films in education also requires careful consideration of their characteristics, challenges, and strategies to optimize communication between students and teachers. When employed in a considered manner, films can transform traditional educational practices and make learning both effective and enjoyable (6, 10, 32).

Traditional teaching methods are often insufficient to meet the diverse learning needs of students, particularly in dynamic and complex disciplines. These methods

typically rely on lectures, textbooks, and recall of information, which may not be effective for students with different learning styles. For example, those who learn visually may have difficulty understanding abstract concepts presented in text-heavy formats, while those who learn kinesthetically may find passive learning methods ineffective. Additionally, traditional approaches' lack of interactive and relatable content can lead to disconnections, impaired recall, and reduced conceptual understanding (15, 26)

Innovative teaching strategies, such as cinemeducation, overcome these limitations by integrating cinematic narratives into the curriculum (6). By transforming complex immunological concepts into compelling visual stories, this approach appeals to diverse learning styles and encourages active participation and deeper understanding. This highlights the imperative to update educational practices to create a more inclusive and effective learning environment (13, 14).

Cinemeducation, using films as teaching tools, has proven to be an innovative and practical approach to education (10). Cinemeducation closes the gap between theoretical knowledge and practical application by integrating cinematic storytelling into the curriculum (8, 11, 18, 35, 36). Films provide a unique medium for visualizing complex scenarios, improving conceptual understanding, and developing critical thinking (2, 3, 4). This approach has been used successfully in various medical disciplines, including pharmacology, ethics, and patient safety, where it has been proven to improve student engagement, empathy, and knowledge retention (17, 27, 28, 31, 34). Cinema education facilitates the utilization of movies' emotional and cognitive impact to enhance the learning process's interactivity and clarity (6, 7, 8). By presenting authentic case studies and immersive narratives, this approach enables students to examine diverse perspectives and establish a connection with the human dimensions of medical practice (27). Consequently, cinemeducation has emerged as a widely accepted pedagogical strategy, transforming traditional medical education into a more engaging and practical experience. The concept of "cinemeducation" is utilized in several countries, including the United Kingdom, Canada, Brazil, Australia, Thailand, India, Ireland, and Saudi Arabia, for the education and training of medical students (11).

The field of immunology is often cited in the literature as a particularly complex and challenging area of study and teaching. This is due to several factors, including the intricate nature of the subject matter, its interdisciplinary nature, and the accelerated pace of scientific advancement in this field (9, 12, 37). Given its multidisciplinary status, acquiring immunological knowledge demands a comprehension of the principles underlying several distinct biological disciplines (5). In the context of immunology education, innovative teaching methods are of particular value due to the complex and abstract nature of the subject matter. Traditional teaching methods frequently prove inadequate for accommodating diverse learning styles, making students distracted or overwhelmed. Implementing cinemeducation, a creative adaptation of film pedagogy, represents a novel strategy for simplifying immunological concepts and fostering active student participation. Integrating cinematic storytelling into the curriculum demonstrates the potential of innovative teaching to transform complex topics into engaging and accessible learning experiences.

The animated superhero *The Incredibles* has been selected as a key film for immunology because of its engaging narrative, relatable characters, and ability to draw creative analogies to the immune system. With its vivid storytelling and dynamic family of superheroes, the film provides an ideal framework for transforming complex immunological concepts into accessible and memorable stories for students. In this approach, each member of the superhero family is associated with a specific component of the immune system. For example, the father, known for his strength, symbolizes T-cells, indispensable defenders of immune responses. The mother, Elastigirl, is analogous to B cells, which adapt and produce antibodies because of her ability to stretch in different directions. With her ability to create protective force fields, the teenage daughter symbolizes antibodies that protect the body from pathogens. The hyperactive son and baby, representing cytokines and potential immune responses, complete the analogy. These representations help students to understand the role of immune components vividly and entertainingly. Cinemimmunology uses the characters and plot of a film to present abstract immunological theories clearly and understandably. The engaging nature of the film captures students' attention, encourages active participation, and promotes long-term retention of essential principles. This innovative use of The Incredibles as a teaching tool demonstrates the power of cinematic storytelling to change medical education and make learning both fun and enjoyable.

Likewise, the way the babies in the film *The Boss Baby* are full of unused possibilities and impact the behavior of others around them, cytokines are signaling molecules that control the immune response. While regular newborns can represent these molecules' latent energy and hidden potential, the protagonist of *The Boss Baby*, a baby with high intelligence and leadership abilities, represents the active role of cytokines in regulating immune responses. The humor in the movie and the focus on infants having a significant influence may be similar to how cytokines can either boost or control the immune system, depending on the context. Interestingly and memorably, this film could assist students in comprehending the dynamic and crucial role that cytokines play in immune responses.

This study aims to assess the efficacy of cinemimmunology as a novel pedagogical approach for fostering students' understanding of immunological concepts and their long-term learning retention. By integrating cinematic storytelling into the curriculum, this research aims to ascertain whether films' engaging, and relatable nature can facilitate students' comprehension of abstract and complex immunological processes. Additionally, this research project aims to offer valuable insights into the potential of innovative teaching strategies to effect a transformative change in how immunology is currently taught, thereby significantly contributing to the broader effort to promote the integration of creative methodologies in higher education.

In our paper, we focus on the following research question:

- Does using movie-based learning improves students' understanding of Basic immunology concepts compared to traditional teaching methods?

2. Literature Review

Cinemeducation in medical and healthcare educational curricula has been extensively investigated, substantiating its efficacy in fostering enhanced empathy, communication abilities, professionalism, and conceptual comprehension across various disciplines. For instance, studies have demonstrated its effectiveness in pharmacology (8), forensic medicine (34), and social work (28).

The utilization of cinematic techniques as an educational resource, otherwise known as cinemeducation, has received considerable attention in medical education. This is due to its capacity to engage students and facilitate a more comprehensive understanding of nuanced subject matter. Rueb et al. (2022) conducted a mixed-methods study to investigate the motivations and benefits of using cinematic media in medical education (33). The study highlighted those films can enhance conceptual clarity, promote empathy, encourage critical thinking, and facilitate long-term retention of information. Furthermore, the study underscored how cinematic storytelling can address diverse learning needs, making it a versatile tool for inclusive education.

The application of cinematic education extends beyond fostering emotional and critical thinking skills to improving technical knowledge in areas of specialization. Cambra-Badii et al. (2020) explored the use of cinema in clinical pharmacology education, with a particular focus on pharmacovigilance and adverse drug reactions. Their study demonstrated how films could be an effective pedagogical tool, illustrating the practical implications of clinical pharmacology concepts and encouraging active student engagement (6). Cambra-Badii et al. (2020) indicated that presenting real-life scenarios in films facilitates students' comprehension of the multifaceted impact of pharmacological decisions, including the significance of monitoring and mitigating adverse drug reactions. This approach is compatible with cinemimmunology, which employs cinematic narratives such as The Incredibles to elucidate intricate immunological concepts. By establishing parallels between immune system components and relatable characters, cinemimmunology facilitates a more profound comprehension and prolonged retention, mirroring the pedagogical efficacy observed in pharmacology education.

The versatility of cinema education as an educational tool has been increasingly acknowledged across various disciplines within the health sciences. Cambra-Badii et al. (2023) demonstrated the broader value of this approach in fostering critical thinking, empathy, and the capacity to connect theoretical knowledge with practical applications (8). Their discussion of cinema education's role in the health sciences emphasized its potential to create engaging and relatable learning experiences, particularly for complex or abstract topics. In their 2024 research, Cambra-Badii and colleagues delved into the potential of cinematic education to augment medical students' comprehension of patient safety. Their study underscored the efficacy of film as a pedagogical tool for simulating authentic healthcare scenarios (7).

The versatility of cinemeducation extends beyond medical and health sciences education to disciplines such as social work, where it plays a vital role in fostering

readiness for practice. Jonathan (2023) investigated the utilization of cinemeducation in social work education, illustrating how films can effectively simulate real-world scenarios and enhance students' critical thinking, empathy, and problem-solving aptitudes (28). This approach enhances conceptual comprehension and prepares students for the complexities of professional practice. In addition, cinema represents an increasingly valuable tool for the education of medical professionals, offering a distinctive medium for the illustration of complex concepts in an engaging and accessible manner. Das (2023) explored the role of cinema in medical education, indicating its potential to enhance learning outcomes by fostering a deeper understanding of theoretical knowledge and its practical applications (11). The study revealed that films can link abstract concepts and real-life scenarios, making them particularly effective in addressing diverse learning needs.

Furthermore, cinemeducation has been widely acknowledged for its contribution to teaching professionalism and ethics, particularly in medical education. In a study published in 2022, Patel and colleagues examined cinematography as a pedagogical tool for undergraduate medical students (31). They found that films can provide vivid and relatable scenarios for discussing complex ethical dilemmas and professional responsibilities. Their findings revealed that cinemeducation is an effective method for understanding patients' feelings, the role of communication, and the teaching of empathy and ethical aspects in patient care. Soni et al. (2023) evaluated its use in teaching forensic medicine to undergraduate students, illustrating how cinematic media can effectively enhance student engagement and comprehension of complex medico-legal concepts (35). In a study published in 2022, Bartwal and Shukla investigated the efficacy of cinemeducation in teaching communication skills to students. Their analysis revealed that films offer realistic scenarios and emotional narratives, which assist students in comprehending the complexities of effective communication, empathy, and patient interaction. The 2022 study by Son explored the integration of cinemeducation into medical professionalism (34). It demonstrated the capacity of this approach to cultivate critical reflection and ethical reasoning among medical students.

One of the most significant advantages of cinemeducation is its capacity to promote empathy among learners, particularly at the medical education level. Tekulapally (2024) investigated the utilization of movie clips to enhance empathy among medical interns, indicating how films can effectively illustrate patient experiences, emotions, and challenges (36).

Cinemeducation has also been shown to have significant potential in nursing education, where it can facilitate experiential and reflective learning. In a study by Goodwin (2021), using films as a creative teaching tool was identified as an effective method for helping nursing students comprehend complex concepts and develop critical thinking skills (18). The study demonstrated that films could provide relatable scenarios, enabling students to engage with challenging topics in a safe and controlled environment while encouraging deeper emotional and cognitive connections. The study by İçen and Tuncel (2024) explored the use of films in social studies education. Using cinematic

narratives, the authors showed the potential of this approach to facilitate deeper understanding, engagement, and contextual learning (27).

Boussif and Sánchez Auñón (2021) analyzed the potential of integrating cinema within the French language curriculum at the secondary level (3). Their findings indicated that using films could facilitate the development of linguistic competencies, cultural awareness, and student engagement. The study accentuated the distinctive capacity of cinema to foster immersive learning environments, thereby enhancing the accessibility and memorability of abstract or complex concepts.

Despite the increasing application of cinema pedagogy in various areas more broadly, the use of this method in teaching immunology remains largely unexplored. Immunology is an essential subject for many students but is also conceptually demanding due to its abstraction and complexity. While traditional pedagogical approaches facilitate understanding, they often prove inadequate to accommodate students' heterogeneous learning styles and varying levels of engagement. This gap provides an opportunity to explore innovative teaching strategies, such as cinema immunology, which combines cinematic storytelling with immunological education.

3. Material and Methods

3.1. Study Design

This study aimed to assess how effectively first and second-year pharmacy students acquired and remembered fundamental immunology principles using cinema education, mainly using an innovative method called "cinemimmunology." The first and second-year students at the College of Pharmacy participated in this study. Two workshops were created to enhance the basic immunology curriculum. Through the characters in Brad Bird's films, *The Incredibles 1* and *The Incredibles 2*, classes used the movie to conceptually symbolize various immune system elements, such as T cells, B cells, antibodies, and cytokines. Students were shown scenes from both films that used the abilities of the characters to symbolically depict immunological functions: the mother's adaptability (B cell), the father's strength (T cell), the daughter's defensiveness (Antibody), and the son's energetic nature (energy of immune response). The baby represented cytokines, or the immune response's unrealized potential. Moreover, cytokines are signaling molecules that regulate the immune response, much like the newborns in the film *The Boss Baby*, with the potential to influence the actions of those around them. After the showing, interactive exercises and guided discussions were conducted to relate these film images to real-world immunological concepts.

3.2. Participants

The first and second-year students at the College of Health Sciences and Pharmacy at Chicago State University participated in this study.

3.2. Collection of Data

Multiple-choice questions, brief responses, and visual reminders intended to evaluate comprehension and memory of immunological concepts were used to assess the efficacy of the cinemimmunology approach (Figure 1).

3.3. Statistical Analysis

Data were analyzed using descriptive statistics (RStudio, Posit PBC, Bosten, MA, USA).

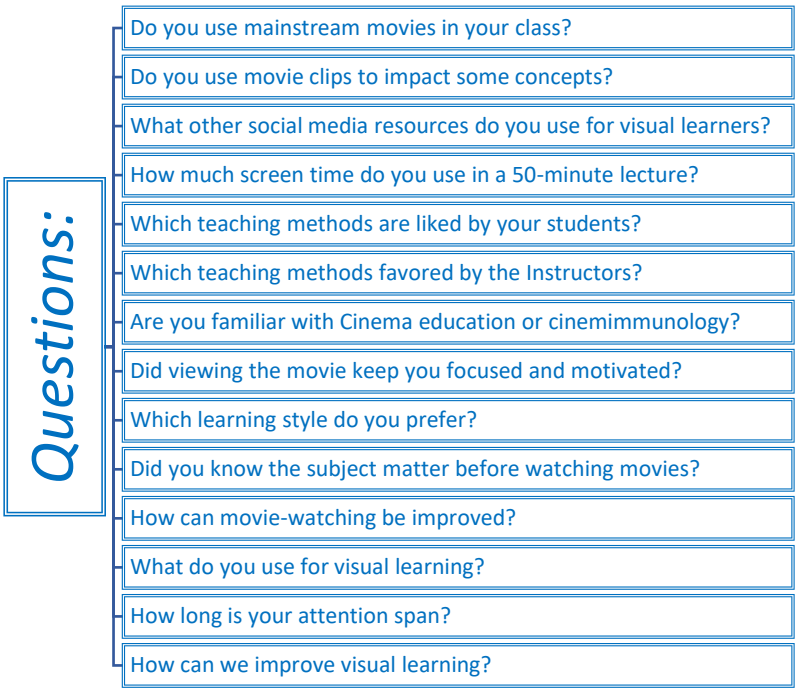

Figure 1: Questions used for the survey

4. Results

The research showed that the film inspired many students (53.7%). This suggests the film's content had a powerful emotional or motivational effect. In contrast, 33.3% of participants expressed engagement, indicating they were actively paying attention to the film's plot or content. Just 13% of participants selected the least common response, "focused," demonstrating that although the movie may capture interest or inspire, it might not necessarily assist with scrutiny. In addition, according to the results, 44 % of the respondents indicated that they did not gain anything from the film, which may suggest that the instructional material or presentation was inefficient for the target audience. On the other hand, 26.7% of participants claimed the movie increased their understanding of the topic, suggesting a valuable addition to their previous knowledge. Another 12.2% of respondents argued that the film expanded their topic knowledge. Notably, 7 % of participants indicated that the film offered them a three-dimensional image of the subject significance, which may indicate an instructional tool that made challenging topics easier to understand. The perceived negative impact of the film was insufficient, as only 5% of the respondents considered it an ineffective use of time.

Moreover, 53.3% of students were not watching the movie. This significant percentage indicates a discrepancy between the audience's attention and the movie's presentation or content. On the other hand, 46.7% of participants acknowledged multitasking, studying for upcoming tests, focusing on different assignments, or regularly becoming distracted.

The study's results indicated a notable inclination towards auditory learning, with 40% of individuals designating lectures as their predominant learning mode. Reading textbooks was the second most favored approach, selected by 20% of the participants. An equivalent percentage chose group discussions, signifying a preference for interactive and collaborative learning settings.

A minority of individuals preferred utilizing study and exam guides (13.3%), films and YouTube videos (6.7%), and a hybrid approach of reading textbooks and attending lectures (6.7%). 6.7% of respondents preferred summarizing the content in a format that could be used for teaching purposes, suggesting an active and output-driven approach to learning. The findings indicated that most participants, 60%, reported having prior knowledge of the subject matter. This shows that these participants were not approaching the content from a basis of foundational learning. Conversely, 40% of the participants indicated they were unaware of the material presented in the films. A similar proportion of participants (20%) advocated using subtitles and captions to facilitate comprehension, particularly for those experiencing difficulties with auditory comprehension or learning a non-native language.

A further 33.3% of participants preferred interrupting the cinematic presentation at scheduled intervals to discuss the underlying concepts. This could prove an effective method of reinforcing the learning points and encouraging active engagement. Furthermore, 26.7% of the participants appreciated pausing periodically for the instructor to explain or clarify.

Using textbook-provided videos was also a common practice, with 73.3% of participants reporting their use. Another frequently utilized tool was Google, employed by 66.7% of respondents. 33.3% of the total students reported an attention span of 20-30 minutes, indicating that this duration may be optimal for maintaining learner engagement in educational sessions. Most respondents (53.3%) indicated that using YouTube channels would be a valuable addition to visual learning.

Furthermore, 26.7% of participants advocated integrating films that align with the specific concepts. This suggests the necessity for contextually applicable visual materials that illustrate and facilitate comprehension of complex subjects through real-world exemplifications and visual narratives.

A minority (10 %) preferred brief video segments, reflecting a potential inclination towards concise and focused content that can convey information in a prompt and engaging format. Only 6% of students perceived the current visual learning tools to be satisfactory, indicating a consensus that significant opportunities for growth exist in this area.

4. Discussion and Conclusion

Incorporating novel pedagogical approaches into pharmacy education is crucial for improving student engagement and comprehension of intricate topics such as immunology. This study used the idea of "cinemimmunology," an adaption of cinemeducation, for first-year pharmacy students through the famous movie "The Incredibles" 1 and 2. We attempted to clarify abstract notions and enhance conceptual learning by correlating the characters in these films with elements of the immune system. Cinematic storylines enabled pupils to correlate recognizable characters with abstract immunological elements. The father's strength corresponds to the vigorous function of T cells, the mother's flexibility signifies the adaptability of B cells, the daughter's invisibility and protective shields represent antibodies, the son's hyperactivity mirrors the swift response of specific immune cells, and the baby's unrealized potential parallels the role of cytokines in immune signaling. The comparison also fostered deeper cognitive connections and made the content more relevant. Our results revealed a substantial improvement in students' comprehension and long-term memory of immunological concepts, suggesting that this cinematic method might be an effective instructional device. Our findings align with prior research that supports the use of cinematic education in medical curriculum. Films engage multiple learning modalities, including visual, auditory, and emotional, facilitating learning for individuals with diverse learning styles and enhancing memory retention. Notably, even students with learning difficulties or disabilities demonstrated significant improvement, indicating that this approach can be an inclusive educational strategy that benefits a broad spectrum of learners.

These outcomes offer insight into the psychological impact of film on an audience and highlight the capacity of cinematic content to exert a considerable influence on viewer motivation. Further investigation could examine the specific film elements that drive each viewer's response.

The distribution of attention and distraction demonstrates a significant challenge in utilizing film as an educational instrument: the requirement to capture and maintain the viewer's attention despite numerous distractions. Additionally, it indicates that individual circumstances, such as impending examinations or other academic pressures, considerably influence the capacity to concentrate on supplementary educational material.

This research demonstrates that students have a wide range of learning preferences, suggesting that instructional strategies should be flexible enough to meet the needs of various learning styles. The information highlights the importance of the need to supply a range of instructional materials and approaches to meet students' various educational demands successfully. The diverse backgrounds of an audience may influence the interpretation and assimilation of academic content. Individuals already familiar with the subject matter may interpret and process information differently than those learning it for the first time. The following point underscores the significance of considering the viewer's background when creating educational videos to ensure that both beginners and experienced individuals can comprehend and benefit from them. The

student's response underscores the imperative for educational films to be inclusive and effectively engage a diverse population by accommodating varying learning preferences and styles. On the other hand, the results obtained about student preferences for visual learning assist in indicating the crucial role of digital platforms and resources in modern education and the relevance of teaching strategies that effectively utilize visual materials. These outcomes illustrate the value of developing a range of teaching strategies that can facilitate shorter and longer attention spans and the variability in individual attention spans. Furthermore, the potential benefits of segmental or flexible educational designs, which allow students to interact with the material in more manageable, shorter periods, are also highlighted. Remarkably, none of those surveyed suggested referring to the instructor's lectures. This may indicate that visual signals are preferred over audio in learning settings, highlighting the importance of imagery in auditory learning resources. These research results support the enhancement of visually stimulating instructional materials, especially those utilizing contemporary digital platforms, to render learning more engaging, accessible, and productive.

Using the movie clip approach in education transcends medical instruction and encompasses a broader educational framework. It amplifies emotions and hence establishes the basis for articulating ideas. Film experiences function as emotional memories, shaping attitudes and reflecting references in daily actions and occurrences. Life tales and stories amplify emotions and establish a basis for communicating ideas. Incorporating a film into classroom education is regarded by students as an enjoyable and inviting alteration, perhaps enhancing their motivation and engagement with the subject matter. In an educational context, films transcend mere diversion from routine practices; they engage interest and cater to several learning modalities, including visual, auditory, and kinesthetic learners. This contrasts the often arid and context-free quality of lectures and textbooks, making it challenging to engage with them meaningfully.

Most students have demonstrated enhanced comprehension and retention of information when presented in a manner that incorporates representation, images, colors, and movement. This phenomenon is particularly prevalent among individuals who exhibit a visual learning style. Furthermore, films may facilitate the development of students' critical thinking abilities, enabling them to analyze the plot, subject matter, and characterization of cinematic works. Integrating academic content with visual narrative in film provides a practical and multifaceted tool for enhancing classroom instruction, increasing accessibility, enhancing interactivity, and improving impact.

While using movies in medical education offers numerous advantages, educators need to be aware of potential drawbacks. One concern is the possibility of oversimplification or distortion. Movies, particularly dramatizations, may portray unrealistic scenarios or exercise artistic license with medical facts, which could lead to misunderstandings. Educators must select movies that accurately represent medical concepts and ensure students can distinguish between fact and fiction.

Furthermore, the utilization of films necessitates the allocation of resources and time. Given the considerable time investment required for full-length films, educators may find it necessary to integrate film screenings into their schedules in a manner that

allows for the accommodation of other curricular elements. One common approach to addressing this issue is to utilize brief excerpts or extracts, provided that they are carefully selected to align with the learning objectives. Ultimately, while films can facilitate students' engagement with a range of moral, cultural, and emotional dimensions of medicine, they must be complemented by structured discussions and introspection. Without adequate guidance, students may not fully grasp the complex concepts in films, limiting the potential for a comprehensive and practical learning experience.

The integration of artificial intelligence (AI) and film may represent a promising avenue for the future of film education. Combining AI's analytical and customization capabilities with cinema's storytelling potential enables educators to create dynamic, inclusive, and profoundly impactful learning experiences. This integration may facilitate children's preparation for a society where technological proficiency, empathy, and creativity are equally crucial. Assessment tools that gauge students' emotional responses to movies ensure the material is engaging and appropriately challenging. To prevent cognitive overload, educators must balance screen-based education and other pedagogical strategies.

4.1 Limitations

It is crucial to consider the limitations of this research despite the encouraging outcomes observed in using films in immunology instruction. Firstly, the study only considered one cohort of first-year pharmacy students at a single university, and the sample size was relatively limited. The applicability of the findings to different student demographics or educational environments is called into question by this restriction. Secondly, despite the popularity of the selected films, it is possible that not all students were equally fascinated by them due to variations in cultural backgrounds, individual interests, or cinematic knowledge. This could have an impact on the overall efficacy of the cinemimmunology approach for a varied student population. Additionally, the effectiveness of immunological principles in real-world, practical circumstances and the long-term retention of knowledge beyond the immediate aftermath of the workshops were not subjected to rigorous evaluation. Furthermore, the potential for bias to influence the results or the level of comprehension may be introduced if self-reported data and assessment results are used.

The absence of a control group or comparison with other cutting-edge teaching strategies represents another disadvantage. Without information, it is difficult to determine whether the cinematic approach is superior to different teaching methods or to attribute any observed advances to it alone. Finally, incorporating entertainment media into academic programs may raise questions regarding academic integrity and the suitability of teaching scientific ideas through fictitious stories. This can cause teachers or students to doubt the legitimacy of the educational process.

Ethics Approval
The Chicago State University (CSU) Human Research Ethics Committee approved the study (Protocol 002-01-21). Informed consent was obtained from all participants in this study.

Availability of data and materials
The datasets used will not be publicly available due to concerns regarding the identification of the participants and in agreement with the ethical approval obtained by the institutional review board. More detailed datasets are available from the corresponding author upon reasonable request.

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Conflict of Interest Statement
The authors declare no conflicts of interest.

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