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Unveiling 21st Century Skills and Chemistry Concepts in the Movie the Martian (2015)

Abstract

In the modern era, 21st century skills and chemistry concepts become very crucial to face global challenges. This study aims to analyse the representation of 21st century skills and chemistry concepts in the film The Martian (2015). This research uses content analysis method with a qualitative approach. The findings show that the film depicts skills such as Problem-solving, collaboration, critical thinking, research skills, effective communication, technological literacy, and adaptability, as well as chemistry concepts such as chemical property/property of oxygen, green chemistry, electro chemistry, chemistry reaction, Stoichiometry, Radiochemistry, physical chemistry, Chemistry Reaction: Reduction-Oxidation reaction. The implications of this study underscore the potential of films as an effective learning medium for teaching scientific skills and concepts that are important in STEM education. It is recommended that educators utilise film as a tool in the learning process.

Keywords: 21st century skills, film, the martian, chemistry concepts

INTRODUCTION

In the modern era, where technological developments and scientific discoveries continue to shape the world, it is important for us to learn 21st century skills and science literacy. These skills are essential to cope with the increasingly complex life and progress of the times. Several studies have stated how important 21st century skills are in preparing individuals to face the challenges of the modern world (Mardhiyah et al., 2021; Mashudi, 2021; Musafa'ah et al., 2024; Putri et al., 2022). In addition, understanding science concepts such as chemistry concepts is also important. Film, as an entertainment medium, is not only a medium of storytelling or entertaining but can also provide valuable insights or lessons for the film's audience. Supporting the idea, due to its audio-visual format, which allows it to convey a lot of information in a brief amount of time, film is also regarded as a potent mass communication tool (Arbi, 2022; Asri, 2020). The Martian, a 2015 film directed by Ridley Scott, is a science fiction film featuring the struggles of an astronaut who is stranded on the planet Mars, and he must implement his knowledge to continue to survive by implementing his intelligence. The film offers a unique opportunity to explore how 21st century skills and chemistry concepts are intertwined in the film's narrative.

The issues addressed in this study stem from the need to better understand how entertainment media such as film can represent and communicate ideas about scientific literacy and essential skills. Despite the educational potential of films such as science education, the analysis of how films such as The Martian portray ideas about science still needs much attention (Rocha et al., 2021). This will have significant relevance to the context of STEM (Science, Technology, Engineering and Maths) education, where learners are encouraged to develop these skills as part of their learning process. This analysis will benefit both learners and educators by providing valuable insights into how the portrayal of 21st century skills and science literacy in films can influence their perceptions.

Although there have been many studies that discuss the concept of science or science literacy such as research conducted by Wardani et al. (2021), and research that discusses the understanding of 21st century skills in films such as research conducted by Perry, (2018). Thus, there is still a gap in the literature regarding the systematic analysis of how a film can simultaneously portray 21st century skills and chemistry concepts. This study aims to address this gap by conducting in-depth content on specific scenes and dialogues in the film The

Martian (2015), identifying and categorising the 21st century skills and chemistry concepts presented. The novelty of this research lies in the integrated analysis of 21st century skills and chemistry concepts depicted in the film The Martian (2015). While many prior studies have focused on the scientific accuracy and narrative aspects of films, this research offers a new perspective by examining how these two elements interact and provide educational insights. The results of this study are also expected to enrich the literature on the use of media in STEM education.

Objective of Study

This study purposes to analyse the representation of 21st century skills and chemistry concepts in the film The Martian (2015).

LITERATURE REVIEW

Skill Abad 21

Several different kinds of skills are necessary in today's environment in order to achieve success. These skills can be identified as 21st century skills which consist of several categories including: 1) Problem-solving, 2) collaboration, 3) critical thinking, 4) research skills, 5) effective communication, 6) technological literacy, 7) career management competencies, and 8) adaptability (Abu-Zaid, 2014; De Fruyt et al., 2015; Rehman et al., 2023). Understanding 21st century skills is crucial because it will help people adjust to the demands of the digital era and equip themselves with the knowledge and abilities needed to compete and contribute significantly in a society that is becoming more interconnected by the day (Arbi et al., 2023).

Chemistry Concepts

In this study, chemistry concepts can be understood as ideas that are relevant to theory, law, and chemistry fundamentals for understanding the nature, structure, and transformation (change) of matter (Guilding et al., 2023). These concept include several topics called chemical reactions, atoms, chemical bonds, thermodynamics, and so forth. This concept has a number of key characteristics. The main characteristics of these ideas include empirical observations, summative analyses, quantitative analyses, as well as the use of scientific methodology.

The Martian (2015)

The Martian is a science fiction genre film that was released in 2015. The story of a Mars exploration is told in this film, which is set in 2035. Massive storm force forced the cancellation of the exploration. The mission's astronaut, Mark Watney, was blown away by a hard object in a mishap, and he vanished in a storm on the planet. Mark had to be abandoned by the entire exploratory team since they believed he was dead. Mark, who was still alive, had to fend for himself on this planet. In order to live, he puts all of his knowledge to use. The show also tells the story of Mark's struggle to survive and the evaluation efforts made by Nasa on earth to save Mark after realising that Mark is still alive. The researchers chose this film as the object of research because the researchers assumed that this film contains values that can represent chemistry concepts and 21st century skills.

METHOD

Research Design

This study adopts a qualitative research design, more precisely content analysis, to analyse the representation of 21st century skills and chemistry concepts in a science fiction

film entitled the Martian. Because it adopts content analysis, this research focuses on the process of identifying and categorising specific scenes and dialogues that illustrate 21st century skills and chemistry concepts. Examining the data qualitatively provides rich insights and significance to these conceptualisations.

Data collection

The primary data of this research contains dialogues and scenes in the film the Martian (2015). Dialogues and scenes that have relevance to the research topic are written in the form of synthesised narratives. The data collection process began with watching the film repeatedly in order to gain a significant understanding of the elements that had been analysed. In the process, the researchers also used field notes to record data relevant to the research topic (21st century skills and chemistry concepts).

Data Analysis

The analysis of the film the Martian (2015) has been carried out by adopting an approach called thematic analysis. The following is the structure or steps of this research data analysis:

1. The researchers identified relevant scenes and dialogues. Each dialogue and scene was carefully reviewed to identify 21st century skills and chemistry concepts. Findings relevant to these skills and ideas were recorded in field notes.
2. The researchers then categorised the findings in the field notes. The findings were categorised according to their respective types and characteristics. Starting from categorising dialogues and scenes that are relevant to 21st century skills, to scenes that reflect ideas about chemistry.
3. The researchers synthesised the research findings.
4. The researchers presented the findings into 2 types of tables. The first one is a table about 21st century skills and the second one is a table about chemistry concepts.
5. Finally, the researchers validated the data.

FINDING AND DISCUSSION

Finding

21st Century Skills Represented on The Martian Movie

The researcher discovered a number of scenes and exchanges that are pertinent to the idea of 21st-century skills based on the data analysis results. The conversations and scenes were combined by the researcher, who then displayed them in a table. Each discovery is categorized into multiple categories of 21st century abilities in the table.

Table.1 Types of 21st century skills represented from The Martian (2015)

No.	Scene	Screen time	21st century skills
1.	*"At the beginning of the film, researchers from NASA (ARES 3 expedition) are carrying out observations of particles on Mars as part of their mission to explore the planet. In the process, they are seen actively communicating and reporting every finding and research progress. They are also always quick to check the equipment they are using."*	00.02.00	• Effective communication. • Research skills • Technological literacy
2.	*"The researchers cooperated with each other, they helped each other when the big storm came, they tried their best to find a*	00.05.00	• Collaboration • Adaptability

	way to survive the storm. The evacuation processes."		
3.	*"After regaining consciousness, Mark Watney attempted to single-handedly treat the injuries he sustained from the impact. He used the tools at hand. With all his might, he extracted the hard object stuck in his stomach and tried to close the wound."*	00.13.05	• Problem-solving • Adaptability • Technological literacy
4.	*"Mark started estimating and counting the food supplies. He also kept a record of the food stocks."*	00.20.90	• Research skills • Critical thinking
5.	*"Mark started thinking and looking for ways to survive. He was looking for a way to grow plants on mars so he could survive."*	00.21.26	• Critical Thinking • Problem-solving • Research skills
6.	*"Mark began to examine the organic waste that would be used as compost mixed with Martian soil, he also began to build his farm by implementing the sciences of botany. In the next minute, he started planting potatoes"*	00.21.49	• Research Skills • Problem-solving
7.	*"Mark realised that for agriculture, he needed a lot of water. He also calculated the amount of water needed."*	00.24.27	• Critical thinking • Research skills
8.	*"Mark started using his ability to produce his own water, applying his knowledge of chemistry."*	00.25.10	• Technological literacy • Problem-solving • Research skills
9.	*"Mark conducted experiments to make water."*	00.26.10	• Research Skills
10.	*"After getting the results of the observations on mars, NASA researchers and high-ranking officials on earth 4embali4 there was a possibility, Mark Wattney was still alive, and they discussed (expressed their respective opinions in order to reach an agreement to save Mark or not."*	00.32.00	• Effective communication • Critical thinking • Collaboration
11.	*"Mark started thinking long-term, he calculated NASA's next mission to Mars, he started calculating the distance where the next mission would take place. And, he figured out how to get to that location so that he could be rescued. He began to experiment to overcome each problem calmly and patiently."*	00.35.08	• Critical thinking • Problem-solving • Adaptability

12	*"NASA researchers on earth observed and calculated the distance Mark travelled during his experiment. Analysing what Mark is doing to solve his problem"*	00.43.27	• Research skills • Critical thinking • Problem-solving
13.	*"Mark is trying to use various means and equipment (technology) to be able to communicate with his colleagues on earth, and Mark's friends are trying to do the same."*	00.48.00	• Effective communication • Technological literacy • Collaboration
14.	*"NASA told him how to hack into the rover (a special vehicle on mars) so he could communicate through the path finder. So that Mark can communicate again with NASA on earth"*	00.52.34	• Effective communication • Technological literacy • Problem-solving
15.	*"Researchers and NASA officials calculated the food stock that Mark could eat and survive for how long with the existing food because of an incident that resulted in Mark's potato crop dying due to an incident Mark accidentally blew up the hab. They also 5embali5m5d Mark's rescue strategy"*	1.06.00	• Critical thinking • Problem-solving • Collaboration
16.	*"Mark communicated online with the team that left him on mars, (the team led by commander Lewis)"*	1.09.00	• Effective communication
17.	*"Mark repaired the damage to the hab caused by the explosion"*	1.09 .57	• Problem-solving
18.	*"The team of astronauts led by Commander Lewis discussed whether they would save Mark by considering various consequences."*	1.28.30	• Critical thinking • Collaboration • Problem-solving
19.	*"Mark, NASA astronauts and NASA members on the ground communicatively and collaboratively made preparations for Mark's rescue mission"*	1.32.00	• Collaboration • Effective communication • Problem-solving
20.	*"Mark prepared for his rescue operation, and the rescue team also prepared and divided the tasks (commander lewis led the discussion), the whole world began to watch the rescue process, all parties began collaborative and communicative rescue preparations."*	1.49.00	• Collaboration • Effective communication • Problem-solving
21	*"Mark gives a briefing or lesson to aspiring astronauts… he talks about his experiences surviving in space"*	2.12.16	• Effective communication

Adopted from (Arbi et al., 2023)

Referring to the data presented in table 1, there are 21 data relevant to the concept of 21st century skills. One data can represent more than one skill. The observation results also gained insight that the film The Martian (2015) represents 7 types of 21st century skills including: Problem-solving, collaboration, critical thinking, research skills, effective communication, technological literacy, and adaptability. So there is one skill that is not found, namely career management competencies.

Chemistry Concept Characteristics represented from The Martian (2015)

In accordance with the objectives of this study, the researchers presented data relevant to chemistry concepts using a table. The table contains some information about the data number, screen time (time of dialogue or scene in the film), and the chemical concept reflected in the data.

Table 2. Chemistry Concept Characteristics represented from The Martian (2015)

No.	Scene	Screen time	Chemistry Concepts
1.	*"The oxygen indicator displays in the film The Martian is repeatedly shown to contain the highest percentage of oxygen around 20-21%. This illustrates the concept of chemistry in understanding the chemical properties of an element, especially oxygen. Oxygen levels are kept around this percentage because it is to resemble oxygen levels in the earth's environment. If it exceeds this percentage, it can increase the potential for danger due to the flammable chemical properties of oxygen."*	00.04.47 (repeatedly shown throughout the film)	• Chemical Properties of Oxygen /Properties of matter
2.	*"Mark Watney as the main character standing in a special area of organic waste shows the application of the Green Chemistry concept in the film. Furthermore, the main character reuses the organic waste obtained from the special organic waste area as fertiliser to grow potatoes on Mars."*	00.21.35	• Green Chemistry
3.	*" Mark Watney is featured several times in the film activating solar panels and utilising solar panels in surviving on Mars which represents the chemical concept of electrochemistry.*	00.21.57	• Electrochemistry
4.	*"A series of scenes of the main character when he encounters water supply problems in surviving on the planet Mars. The main character solves the water supply problem using chemical concepts from*	00.24.57	• Chemistry Reaction • Stoichiometry

	chemistry reaction and stoichiometry. The application of the concept begins with the main character describing the recipe for making water supply from the decomposition of hydrazine into H2 and N2 with the help of an Iridium catalyst. Chemically the reaction can be written $N_2H_4 \rightarrow N_2+2H_2$ *(Iridium catalyst). Then the formation of water from burnt hydrogen gas is written* $2H_2+O_2 \rightarrow 2H_2O$ *where oxygen* (O_2) *is depicted as a flame in the scene."*		
5.	*"The main character in the film is faced with the problem of using a body heating device in the Rover vehicle while on Mars. After a certain time the main character finds a solution by using the carcass of the Radioisotope Thermoelectric Generator (RTG). The main character understands that the RTG contains radioactivity in the form of Plutonium so that utilising the RTG carcass for heating is done carefully, namely by re-covering it with a yellow lid to protect it from the danger of radiation from the Plutonium RTG element. The chemical concept of the scene is an illustration of the concept of radiochemistry."*	00.36.41	• Radiochemistry
6.	*"The scene of one of the Mars exploration team named Vogel shows the physical form of water (H2O) floating in the spaceship while entertaining his family on earth. The chemical concept shown in the scene is physical chemistry where the water compound (H2O) has surface tension so that it is possible to maintain a perfectly round shape even though there is no gravity in space."*	01.35.35	• Physical Chemitry or Surface Tension
7.	*"The series of scenes of Mark Watney's team in the Hermes aircraft faced the obstacle of saving Mark in Mars orbit. The solution is to blow up the VAL which is part of the Hermes aircraft. If VAL is successfully detonated, it will make it easier for the*	02.00.59	• Chemistry Reaction: Reduction-Oxidation reaction

	Hermes aircraft to approach Mark Watney in Mars orbit. Vogel, who is a chemist in the team, was assigned to make a bomb from the materials in the Hermes aircraft. The materials presented by Vogel such as sugar (organic substances), liquid oxygen, and stain remover containing ammonia where the combination of these substances is claimed by Vogel to be 5x stronger than a stick of dynamite activated by a lighting panel in VAL. The concept of chemistry related to explosives shown in the film is chemistry reaction, especially the concept of reduction-oxidation reaction, namely from several organic compounds mixed with oxygen as the oxidiser of the bomb. Where in the film the bomb-making scene is successfully carried out for the emergency purpose of rescuing Mark from Mars orbit so that he can rejoin the team in the Hermes aircraft."		

Adapted from (Wardani et al., 2021)

Reflecting on the data displayed in Table 2, it can be said that there are 7 data that represent chemical concepts. These ideas can be classified into chemical property/property of oxygen, green chemistry, electro chemistry, chemistry reaction, Stoichiometry, Radiochemistry, physical chemistry, Chemistry Reaction: Reduction-Oxidation reaction.

Discussion

Based on the findings, this research has identified some 21st century skills and chemistry concepts that have been represented in the film The Martian (2015). The findings have shown how educational elements (21st century skills and science) are integrated in popular media such as films.

21st Century Skills in The Martian Film

Based on the analysis, there are twenty-one scenes or dialogues in the film that are relevant to 21st century skills such as problem-solving, collaboration, critical thinking, research, effective communication, technological literacy, and adaptability. For example, the researchers from NASA actively communicating and reporting their findings shows the importance of effective communication, Mark Watney also shows his critical thinking and research skills through the scene where he calculates food supplies and looks for ways to survive. However, this study did not find career management competencies, suggesting that there are still 21st century skills that have not been explored in this film.

Chemistry Concepts in The Martian Film

This research has also found seven main chemistry concepts in The Martian film. These concepts include the chemical properties of oxygen, green chemistry, electrochemistry, chemical reactions, stoichiometry, radiochemistry, and physical chemistry. For example, Mark Watney applies the concept of chemical reactions to produce water from hydrazine. The

scene shows the practical application of stoichiometry and chemical reaction concepts. The film also illustrates the concept of green chemistry through the use of waste to make it into organic fertiliser when planting potatoes.

Reflection on findings

Overall, the findings of this study confirm that The Martian film does not only function as entertainment, but also as an educational medium as it can enrich the understanding of 21st century skills and scientific concepts, particularly in STEM education. As Wardani et al. (2021) stated, popular media such as films can be an effective tool in learning. This can be true if the film is able to integrate elements that are relevant to real life. This means that The Martian can be seen as an important example of how films can be used to teach and reinforce critical skills and scientific concepts needed to face the challenges of globalisation and evolving technology.

Implications of the study

This research has significant and positive implications for the world of education, especially in learning 21st century skills and chemistry concepts. Based on the findings of this study that describe problem-solving, critical thinking and collaboration skills, this study can show the potential of film as an interesting and effective learning media. Teachers can utilise the film to teach these skills in various subjects, especially science and technology, where 21st century skills are needed. The use of popular media such as film in learning can also increase students' motivation and engagement, as suggested by several education experts.

In addition, the film's representation of chemical concepts, such as stoichiometry and chemical reactions, provides concrete examples that can strengthen students' understanding of the material being taught. The film can also be used to teach the principles of green chemistry and sustainability, which are increasingly significant in the education curriculum today. The use of media such as film in this context can help bridge the gap between theory and practice. In addition, it also prepares learners for real-world challenges. Therefore, educators are advised to consider the integration of The Martian in their learning process.

Strengths and Weaknesses of this Study

The strength of this research is the method or approach used. The approach used is an innovative approach in analysing a popular film (The Martian) as a resource to teach 21st century skills and chemistry concepts that provide a new perspective in the educational context. The use of visual media helps to concretise complex theories, thereby facilitating student understanding. However, there are limitations to this research in terms of generalisation of findings. This study only focused on one film so it may not cover all aspects of 21st century skills and chemistry concepts that are relevant in a broad educational context.

CONCLUSION

This research successfully revealed that the film The Martian (2015) not only provides entertainment, but also illustrates various 21st century skills such as Problem-solving, collaboration, critical thinking, research skills, effective communication, technological literacy, and adaptability as well as some relevant chemistry concepts. Thus, this film can be used as an interesting and effective educational tool in teaching 21st century skills and chemistry concepts in the modern era. For future research, it is recommended to extend the analysis to other films or different media that also contain 21st century skills and scientific content, in order to enrich educational resources. In addition, direct integration of the film in the educational curriculum could be tested to see its impact on students' understanding.

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