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ANIMATION OF BORON NEUTRON CAPTURE CANCER THERAPY

Indra Maulana[1*]

[1]Amikom University
**Corresponding author: indra.maulana@rocketmail.com*

Abstract One of the most common causes of death in the world is cancer. Scientists have been trying to find the best cure for cancer ever since it was discovered. There are some ways that are used to treat cancer patients. Lately, scientists have developed a new way in treating cancer, it's called Boron Neutron Capture Therapy (BNCT). BNCT is a selective cancer therapy, it only selects the cancer cells to be treated and leaves the normal cell untouched. It may have no effect or only a little effect on normal cells. As new knowledge that needs to be known by all people, what is the best way to introduce BNCT? What is the best media to introduce BNCT? Is it enough to just read it in a newspaper or in a book? How about using advanced technology such as animation to introduce BNCT? The use of animation as a form of media to introduce something new is already being done in many fields. Can animation be used as a form of media to introduce BNCT too? Will it be effective? By this study, the author gives information about the effect of using animation as a tool to explain and understand BNCT more.

Keywords BNCT, cancer, animation

1. INTRODUCTION

Cancer is the second leading cause of death globally, and was responsible for 8.8 million deaths in 2015. Globally, nearly 1 in 6 deaths is due to cancer. Approximately 70% of deaths from cancer occur in low- and middle-income countries. Around one third of deaths from cancer are due to the 5 leading behavioral and dietary risk factors: high body mass index, low fruit and vegetable intake, lack of physical activity, tobacco use, and alcohol use (Plummer et al., 2016). As the second cause of death in the world, scientists keep looking for the best cure for cancer. Nowadays there are several types of treatment that are used to treat cancer patients such as:

1. Surgery

Cancer is often treated with the surgical removal of cancerous glandular tissue, as well as some surrounding tissue. Minimally invasive surgical treatment methods can help to reduce healing time and minimize the risk of infection after surgery ("Adenocarcinoma - Cancer Types & Treatment Options CTCA," n.d.).

Possible complications during surgery may be caused by the surgery itself, the drugs used, and the overall health of the patient. Generally speaking, the more complex the surgery is, the greater the risk of side effects.

Minor operations and taking tissue samples (biopsies) usually have less risk than a bigger surgery. Pain at the surgery site is the most common problem. Infections at the site and reactions to the drugs used to numb the area (local anesthesia) are also possible.

Some side effects are possible during and after surgery. Generally, these side effects are not expected to be life threatening. They can include: bleeding, blood clots, damage to nearby tissues, drug reactions, damage to other organs, pain, infections and slow recovery of other body function (C. A.

Society, n.d.).

2. Radiation Therapy

This treatment option is typically used in combination with surgery and/or chemotherapy. Advanced radiation therapies make use of image guidance before and during treatment to target tumors, while sparing healthy tissues and surrounding organs (America, n.d.).

Radiation therapy can cause early and late side effects.

Early side effects happen during or shortly after treatment. These side effects tend to be short-term, mild, and treatable. They're usually gone within a few weeks after the treatment ends. The most common early side effects are fatigue (feeling tired) and skin changes. Other early side effects usually are related to the area being treated, such as hair loss and mouth problems when radiation treatment is given to this area.

Late side effects can take months or even years to develop. They can occur in any normal tissue in the body that has received radiation. The risk of late side effects depends on the area treated as well as the radiation dose that was used. Careful treatment planning can help avoid serious long-term side effects. It's always best to talk to your radiation oncologist about the risk of long-term side effects (A. C. Society, n.d.-b).

3. Chemo Therapy

Chemotherapy treats cancer with drugs that destroy cells, either throughout the whole body, or in a specific area. In some cases, chemotherapy may be used in combination with other forms of treatment (America, n.d.).

Cancer cells tend to grow fast, and chemo drugs kill fast-growing cells. But because these drugs travel throughout the body, they can affect normal, healthy cells that are fast-growing, too. Damage to healthy cells causes side effects. Side effects are not always as bad as you might expect, but many people worry about this part of cancer treatment.

The normal cells most likely to be damaged by chemo are blood-forming cells in the bone marrow, hair follicles and cells in the mouth, digestive tract, and reproductive system.

Some chemo drugs can damage cells in the heart, kidneys, bladder, lungs, and nervous system. Sometimes, you can take medicines with the chemo to help protect your body's normal cells. There are also treatments to help relieve side effects.

Doctors try to give chemo at levels high enough to treat cancer, while keeping side effects at a minimum. They also try to avoid using multiple drugs that have similar side effects (A. C. Society, n.d.-a).

4. Targeted Cancer Therapy

Targeted therapy is a special type of chemotherapy that takes advantage of differences between normal cells and cancer cells. It's sometimes used alone, but most often other treatments are used with targeted therapy. Targeted therapy drugs don't work like chemo drugs. These drugs target certain parts of cancer cells that make them different from other cells. (Or they may target other cells that help cancer cells grow) (A. C. Society, n.d.-d).

Although targeted therapy drugs don't affect you the same way that standard chemo drugs do, they can still cause side effects. There are many different types of targeted drugs, and the side effects from these drugs

depend largely on what each drug targets.

Not every person gets every side effect, and some people get few, if any.

Some of the other common and serious side effects caused by targeted therapy drugs are high blood pressure, bleeding or blood clotting problems, slow wound healing, heart damage, autoimmune reactions and swelling (A. C. Society, n.d.-c).

5. Immunotherapy

Immunotherapy is a treatment that uses certain parts of a person's immune system to fight diseases such as cancer. This can be done in a couple of ways:

1. Stimulating a person's own immune system to work harder or smarter to attack cancer cells.
2. Giving a person immune system components, such as man-made immune system proteins.

Some types of immunotherapy are also sometimes called biological therapy or biotherapy. Immunotherapy can cause side effects, which affect people in different ways. The side effects someone may have and how they make them feel will depend on how healthy they are before treatment, their type of cancer, how advanced it is, the type of therapy they are getting, and the dose. Doctors and nurses cannot know for certain how they will feel during treatment. The most common side effects are skin reactions at the needle site. These side effects include pain, swelling, soreness, redness, itchiness, rash (Institute, n.d.).

Boron Neutron Capture Therapy (BNCT) is included as a targeted cancer therapy. Boron Neutron Capture Therapy (BNCT) is an experimental radiation therapy used in Europe, Japan and the USA (Akan et al., 2015). BNCT was introduced in the 1960's, but showed little development, as the thermal and epithermal neutron sources were not economical. Nuclear reactors and recently cyclotrons are being used as neutron sources, thus enabling its widespread utilization (Akan, 2015). BNCT is potentially a very useful cancer treatment modality; however only a few facilities are available for clinical trials, since all these facilities are currently based on a nuclear reactor source (Fantidis & Antoniadis, 2015).

As one of the newly developed cancer treatments, BNCT will always need new developments in the future. Before being developed further BNCT needs to be introduced, so people will know more about BNCT, understand about the process, the tools that are used and why it's safe to be applied to cancer patients. There are many forms of media to introduce BNCT, one of them is animation. Animation is currently a rapidly developing field of IT that has found wide application in many fields (Dziedzic, Barszcz, Paśnikowska-Łukaszuk, & Jankowska, 2015). The use of animation to introduce or learn new knowledge is already done in many fields. Through this research, we will find out the result of using animation to introduce BNCT.

THEORY AND DEFINITION

Cancer

Cancer is a generic term for a large group of diseases that can affect any part of the body. Other terms used are malignant tumors and neoplasms. One defining feature of cancer is the rapid creation of abnormal cells that grow beyond their usual boundaries, and which can then invade adjoining parts of the body and spread to other organs, the latter

process is referred to as metastasizing. Metastases are a major cause death from cancer (Plummer et al., 2016).

BNCT

BNCT represents a top therapeutic method that relies on nuclear technology knowledge, chemistry, biology as well as on medicine experience in treating malignant tumors (GN & AM, 2015). In theory, Boron Neutron Capture Therapy (BNCT) selectively kills the cancerous cells and does not affect, or has little effect on the normal cells. It works on the principle of the nuclear reaction, when the non-radioactive boron captures the neutron and becomes unstable. Boron neutron capture therapy (BNCT) is a binary radiation therapy modality proposed as an alternative treatment for tumors. The two major components of the therapy are a stable isotope ^{10}B of boron that can be concentrated preferentially in tumor cells and a beam of low energy neutrons. In practice boron-10 (^{10}B), which is a nonradioactive constituent of the natural element boron, is irradiated with low-energy thermal neutrons to yield high linear energy transfer (LET) α particles (^{4}He) and recoiling lithium-7 (^{7}Li) nuclei. For the success of the method, first of all we have to selectively deliver the required dose of boron to the cancerous cells and enough thermal neutrons must be absorbed by the boron, which is present in the cancerous cells. For the selective delivery of the boron we can use the antibody based selective drug delivery system or any other selective drug delivery system (Zahra, 2016), (Elshahat, Naqvi, & Maalej, 2015). Because the high LET particles have limited path lengths in tissue (5-9 μm), the destructive effects of these high-energy particles is limited to boron-containing cells. Since the BNCT method requires a source of neutrons, it requires a nuclear reactor or it can be performed in the hospitals where the alternative source of neutrons is available. A beam of epithermal neutrons penetrates the brain tissue, reaching the malignancy. Once there the epithermal neutrons slow down and these low-energy neutrons combine with boron-10 (delivered beforehand to the cancer cells by drugs or antibodies) to form boron-11, releasing lethal radiation (alpha particles and lithium ions) that can kill the tumor(Haapaniemi et al., 2016).

Irradiation

Irradiation is the use of high-energy radiation from x-rays, gamma rays, neutrons, and other sources to kill cancer cells and shrink tumors. Radiation may come from a machine outside the body (external-beam radiation therapy) or from materials called radioisotopes. Radioisotopes produce radiation and can be placed in or near the tumor or in the area near cancer cells. This type of radiation treatment is called internal radiation therapy, implant radiation, interstitial radiation, or brachytherapy. Systemic radiation therapy uses a radioactive substance, such as a radiolabeled monoclonal antibody, that circulates throughout the body. Irradiation is also called radiation therapy, radiotherapy, and x-ray therapy(MedicineNet, n.d.).

Animation

Animation is a process of creating a series of images appearing one after another, synchronized into a single whole and causing the so-called image animation effect (Dziedzic et al., 2015). Animation can be utilized in the learning environment as an

effective tool to educate (Kumar, 2016). Animation can be used as a form of delivery media where learning can be conducted as occurring (1) from technology, (2) with technology, (3) around technology, (4) through technology, and (5) assisted through technology. Animation refers to a computerized simulation of processes using images to form a synthetic motion picture. It is a process of putting still images together in a sequence or manner so they will appear one after the other, creating the illusion of movement. One can feel or see the images as if they are moving. In the context of learning animation assists learners to visualize a dynamic process, which otherwise may be difficult to visualize (Zahra, 2016). From picture galleries to complicated numerical simulations, animation provides a complementary learning experience (Xiao, 2013).

METHOD

To introduce BNCT, the animator made an animation that has some basic information that is needed to explain further about BNCT. The animation shows the basic process of BNCT and some tools or materials that are used. To make the animation the animator does some research and collects some information about BNCT that is needed to make the animation. After collecting enough information, the animator made the animation. In making the animation there are several steps taken by the animator, which are pre-production, production and post-production.

Pre-production

In pre-production, the animator collected all the information that is needed about BNCT. After collecting enough information the animator made the script about how the animation will be animated.

Production

After making a simple script the animator started to make the animation. The animator made the animation based on the script made previously.

Post Production

In post-production, the animator rendered, edited, and inserted sounds that are needed into the animation. These are some scenes from the animation:

1. Nuclear Reactor

In this animation the source for BNCT is a nuclear reactor. The animator made the basic shape of a reactor because some people may have never seen or known the shape of a nuclear reactor.

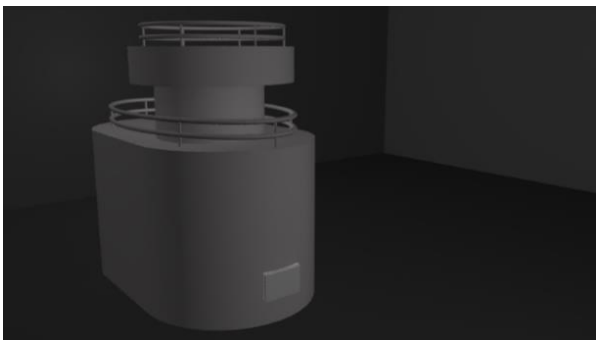

Fig. 1 Image of a nuclear reactor in the animation

2. Reaction

Inside the nuclear reactor there is chain reaction that happens as a result of fission of U235 and neutrons. The animator animates that reaction.

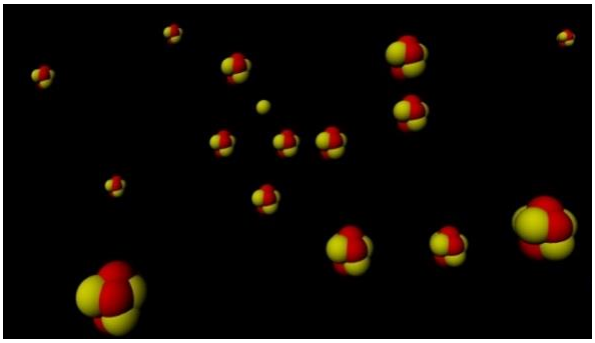

Fig. 2 The chain reaction inside the nuclear reactor.

3. Beam Port

A beam port is a port that is used to shoot thermal neutrons from the inside of the reactor to test the subject in this case.

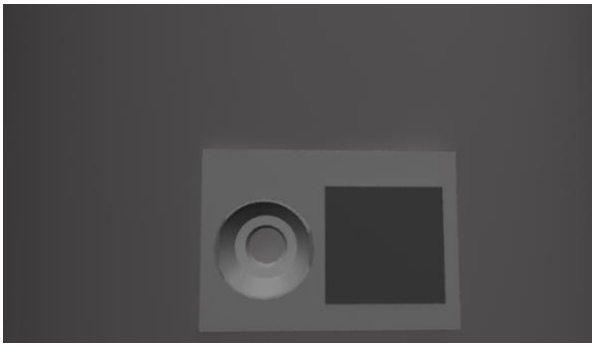

Fig. 3 Picture of a beam port.

4. Collimator

A collimator is designed to shape the thermal neutrons. A good collimator should have a low absorption cross section for epithermal neutrons (Kasesaz, Khalafi, & Rahmani, 2013).

Fig. 4 Image of a collimator in the animation.

5. Shielding

Like the name shielding, its purpose is to shield or block the thermal neutrons. So, it is kept and secured in the area of experiment and prevents it from spreading out. The shielding is made up of paraffin.

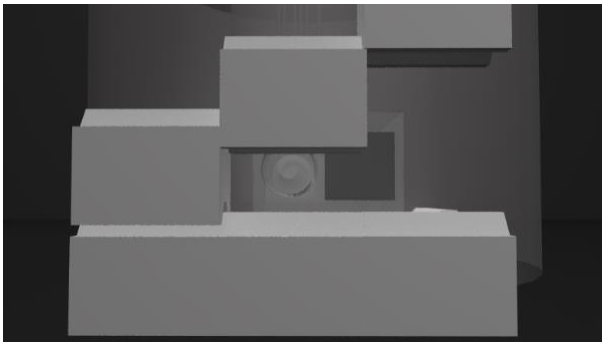

Fig. 5 Arranging the shielding.

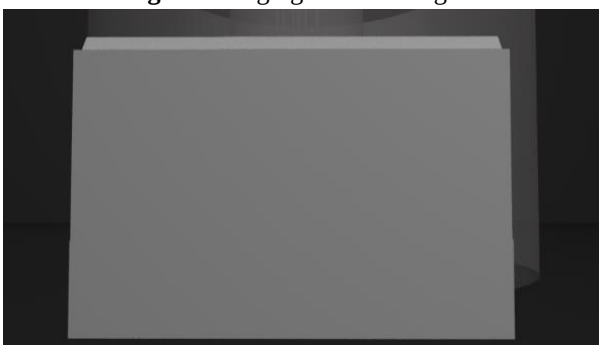

Fig. 6 Shielding is arranged.

6. Irradiation

Irradiation is the process of exposing objects to radiation, the source of exposure is a nuclear reactor. Before it is irradiated, the sample cell is injected by boron and then shot with thermal neutrons.

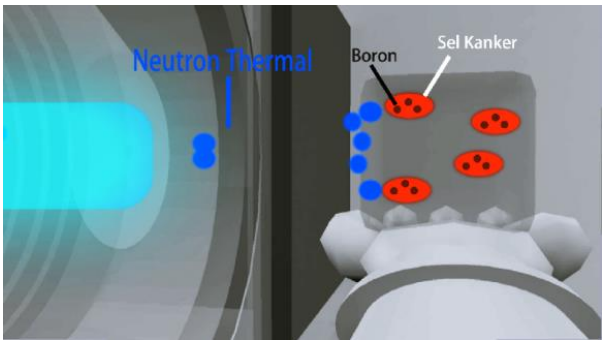

Fig. 7 The irradiation process.

7. Cancer Cell Reaction

BNCT derived from the tendency of a ^{10}B nucleus to capture thermal neutrons. As a result, the unstable nucleus of ^{11}B generates a lithium ion and an α particle. The yields of this reaction have high LET characteristics. Thus, it is able to selectively irradiate cancer cells which have received an appropriate amount of ^{10}B (Zargarzadeh, 2013). This is how the animator animated the process:

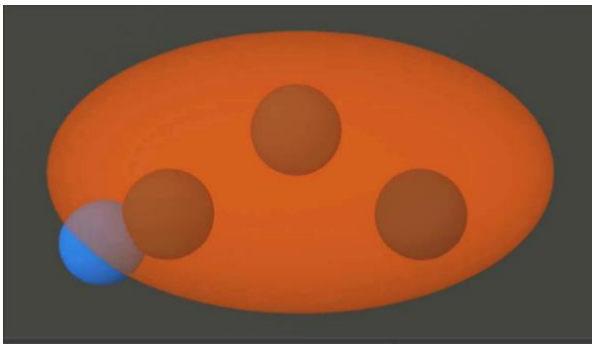

Fig. 8 Thermal neutrons move towards the boron.

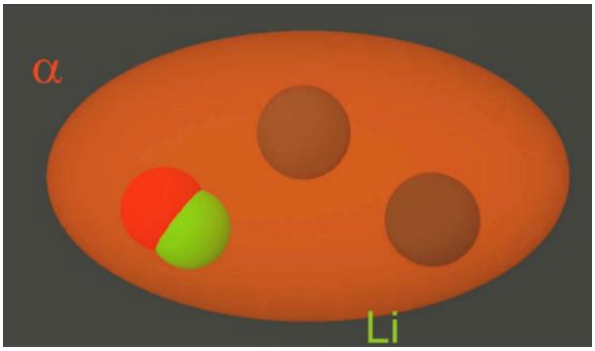

Fig. 9 A lithium ion and an α particle are generated.

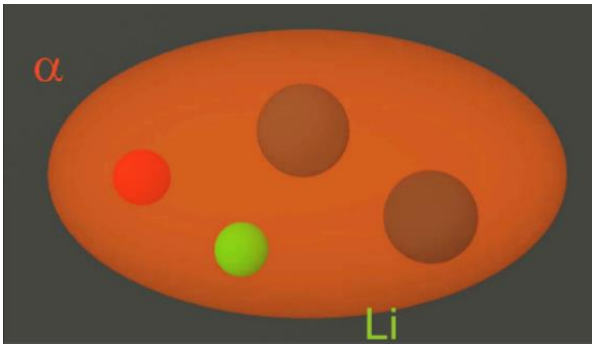

Fig. 10 A lithium ion and an α particle move against each other and are fading.

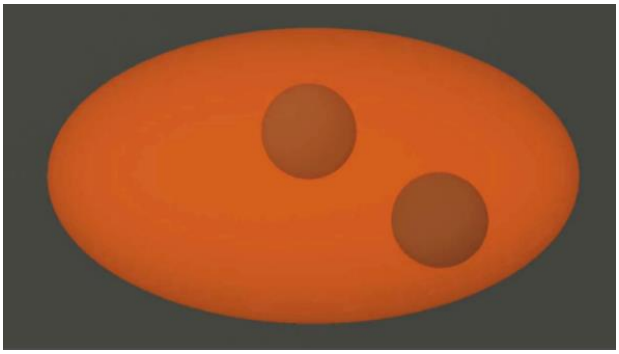

Fig. 11 A lithium ion and an α particle have fully disappeared.

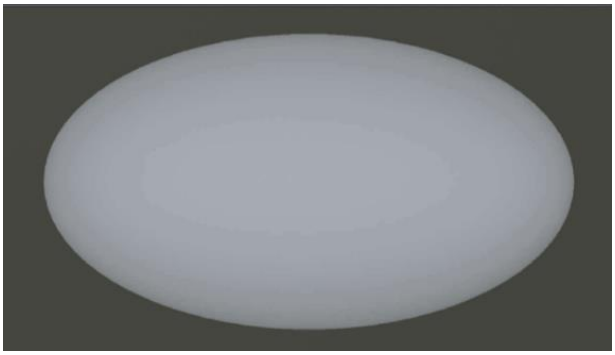

Fig. 12 A treated cancer cell left the cell healthy.

RESULTS

BNCT is known as one of the best cancer treatments. The following are some research results that show the usefulness of BNCT.

1. The research shows that favorable results can be obtained in newly diagnosed GBM patients treated by BNCT (Kageji et al., 2014).
2. On the basis of the analysis of the limited data available, BNCT with BSH might be equivalent to or better than RT alone (Sander, Wosniok, & Gabel, 2014).
3. Boron neutron capture therapy given after prior external beam radiation therapy is well tolerated. Most patients responded to BNCT, but long-term survival with larynx preservation was infrequent owing to cancer progression. Selected patients with recurrent

laryngeal cancer may benefit from BNCT (Haapaniemi et al., 2016).

4. Breast cancer is the most common cancer among females, and particularly recurrent breast cancers (RBC) are threatening for women. Radiation therapy is commonly the preferred method of treatment, but has some side effects and insufficient effects against RBC. Recently, BNCT comes to the fore as an alternative approach to therapy. Successful in vitro and simulation studies have led scientists to anticipate successful clinical results in the near future. Maximization of BNCT's therapeutic potential requires the combination of a suitable thermal/epithermal neutron flux in association with a selective intake of 10B-boron nuclei in the target tissue. With new boron carrier design ns and neutron sources, BNCT can fill an important niche for those malignancies, whether primary or recurrent, for which there is currently no effective therapy(Akan, 2015).
5. The study of BNCT for advanced or recurrent tumors revealed that BNCT-related morbidity and mortality were acceptably low. This study warrants the clinical trial in the planning stage with full consideration of the eligibility criteria, especially in regard to the maximum tumor depth and histology (Suzuki et al., 2014).

Animation is already used to teach, to inform and to educate in many fields. These are some research results that show the use of animation that affect the understanding

1. The rampant growth in the field of information and communication technology has changed the dynamics of teaching and learning. The use of instructional tools like animation in education is proving very effective. Animation has the potential to offer new and improved learning opportunities (Profile, 2017).
2. The utilization of multimedia technology can fully improve the students' thinking and practical language skills. This will ensure and fulfill an effective result of English language teaching. Despite some disadvantages of using multimedia technology in teaching, multimedia technology can be used effectively in English language teaching classrooms. Overall, the non-native speakers of English as language teachers can teach English more efficiently if they use multimedia technology (Pun, 2014).
3. Multimedia plays an important role in enhancing education because it is flexible and has a variety of elements such as animation, audio, video, graphics, and text which if designed appropriately can be effective for learners in a learning situation. Animation as a multimedia element contains all the other elements by forming a combination that is rich in presentation and delivering information (Badi, Zeki, Faris, & Othman, 2013).
4. The perception of students is that technology has an important role in learning mathematics. From the perspective of mathematics students there is a need for the integration of technology into the learning of mathematics by taking into account pedagogical concepts, learning

mathematics more meaningfully by constructing knowledge by combining three concepts, namely content, pedagogical and technological concepts. This study shows many of the benefits of using flash animation. Perceptions of mathematics students showed it to be very beneficial in terms of their experience. It was seen from the view that animation helped students understand math more meaningfully, connecting math to the real world, visualization, and understanding the importance of mathematics (Salim & Tiawa, 2015).

5. This study shows a significant gap between the academic achievements of students in a basic electronics course, who studied the subject of the BJT through animation and the achievements of their peers who studied it using static diagrams. This gap was maintained in advanced electronics courses and even a year after the completion of the introductory course, the achievements of students who studied the subject of the BJT through animation remained significantly higher than those of their colleagues. These findings suggest that for the case of the BJT, animation-based learning has a long-term effect, as it enhances retention and transfer (Gero & Zoabi, 2014).

The example research results above show that the use of animation gives good effects in understanding information that is given, just as BNCT, as one cancer treatment that gives good effects to the medical world, gives more alternatives for cancer treatment. That's why one of the best ways to inform about BNCT is through animation.

The result of this study shows the general process of BNCT from the beginning until the end through animation. The animation makes the information clearer and easier to understand about the basics of BNCT, its process and why it is safe to use.

CONCLUSION

Based on this study, the author concludes that the use of animation to educate or to introduce BNCT makes the information easier to comprehend. Through animation, the viewers are able to imagine the process of BNCT, how it works and what are the materials or tools that are needed or used.

This study also shows that BNCT is one of the most effective cancer treatments that exists right now, and scientists are still working on developing BNCT treatment to make it more effective.

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