

Sci-Art: Visual art approach in Astronomy of teacher education students

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ABSTRACT: *In today's educational predicament, innovative pedagogies must also be conducted. To innovate, one must develop. Scientific numeric data could only be reimagined through visual arts. Students have difficulty explaining and many conceptions towards astronomy. This mixed-method educational action research design assesses the dilemma and determine its effects towards learning. The participants are a total of 30 first year BSED Students who are taking astronomy as their major subject. Two instruments were utilized in gathering data, including: assessment test composing of 100 items question and structured interview guide. Based from the findings, it concludes: after the application of intervention, the STEs are outstanding; there is significant difference between the pre-test and post-test; there are 4 forms of visual arts produced, painting, digital art, diorama and drawing; there are 7 themes emerged, includes (a) Unleashing Creativity; (b) Enhancing Visualization; (c) Understanding Made Easier; (d) Positively Affecting Metacognition; (e) Learning Easily; (f) Memorizing Easily; and (g) Developing Critical Thinking. The study recommends implementation of the intervention in astronomy discipline; develop and explore more forms of visual arts approach that can be implemented in the course; utilize the intervention to make the concepts in astronomy be more easier to understand.*

Keywords-*astronomy, science teacher education, visual arts approach*

I. INTRODUCTION

In this time of pandemic, the educational system has been greatly disrupted and experienced a desperate and sudden shifting from the traditional conventional class into online distance learning. It changed the whole pedagogical practices that teachers and students had been accustomed decades before. Now, that many of our known pedagogies are not effective, unique and feasible pedagogies must be tried and conducted.

For change to exist, humans must know to develop. Artists discern and present various perspective and designs through creative visuals. Scientist sees and perceive viewpoints in a systematic, organized research evidences through meticulous hypotheses and testing. As Jones (2016) stated, that there is a direct relationship between science and art. Because scientific perception could be seen through visual arts. Like looking at a nebula and see a majestic visual." Through this, arts enhance creative thinking which is superbly essential in problem – solving skills which the science students ultimately needed.

According to Rupert (2006) that those of engage in learning visual arts, heighten the achievements in other aspects of learning and life. When visual arts coalesce with science education, the 21st century teaching may undergone a huge metamorphosis shifting from human to mechanical labor based from human passion and innovation. When Problems emerge, it could be solved through the application combined arts and science (Izadi, 2017).

As a Science Education Student and future teacher, the essential components to have are; perseverance, awareness, resourcefulness, excitement, openness, passion and acceptance to fail which Visual Artists and Scientists possessed. Creativity and imagination, inspiration, perseverance, and passion are required for good teachers to have (Green & Tsodikova, 2018).

Aside from the essentials to be possessed, it has also affects learning. Findings in the study of Goldberg (2005) revealed that "Through metacognition, a visual artists could process, strategize and create a solution to a problem, which is undeniably done by the students." That means that students doing art more like affected and elevate their thinking process and have a positive impact on learning. The students who utilize visual arts have significantly improved their academic performance (Punzalan, 2018).

According to De Greve (2009) that Astronomy discipline is fascinating. Subject with fascination of the mysterious and beyond reach. Though, mechanisms, concepts and grasps across fundamental sciences were utilized. With its foundations in Mathematics and Physics, it is a discipline that stretched horizontally across different fields: Biological Sciences, Social Sciences, Earth Sciences, and Technology (Garcia, 2009).

According to Shan (2016), “In astronomy, the data from most of the breakthroughs are just numerical figures and graphs. For the general public to comprehend, the artists’ ability to generate visualization is extremely significant. The visualization such as photos, diagrams, and materialized models have always been essential tools in teaching. The formation of visualizations proves importance in the learning process, especially in science (Gilbert, Reiner &Nakhleh, 2008).

According to the results of a study by Canlas (2013) revealed that university students possess cross multi conceptions along the specific astronomical phenomena and concepts. Though, these students have studied this from primary to tertiary curriculum, they have experienced difficulty explaining the everyday astronomical phenomena In summary, among these students, there is a huge gap with limited knowledge and several misconception existing in the conceptual understanding in astronomy. Therefore, it is recommended to address these dilemma (Trumper, 2000).

The study aims to assess how visual art approach in astronomy subject may fruit the Bachelor of Secondary Education Major in General Science students in acquiring and understanding astronomy concepts.

Conceptual Framework

In pursuant R.A. 7722 with the mandate of CHED, education shall: “promote and exercise a relevant and quality education, guarantee and protect academic freedom for continuing intellectual growth, advancement of learning and research.” An interdisciplinary project of seemingly dissimilar subject matter, arts and science, has enormous pedagogical value (Needle et.al. 2007).

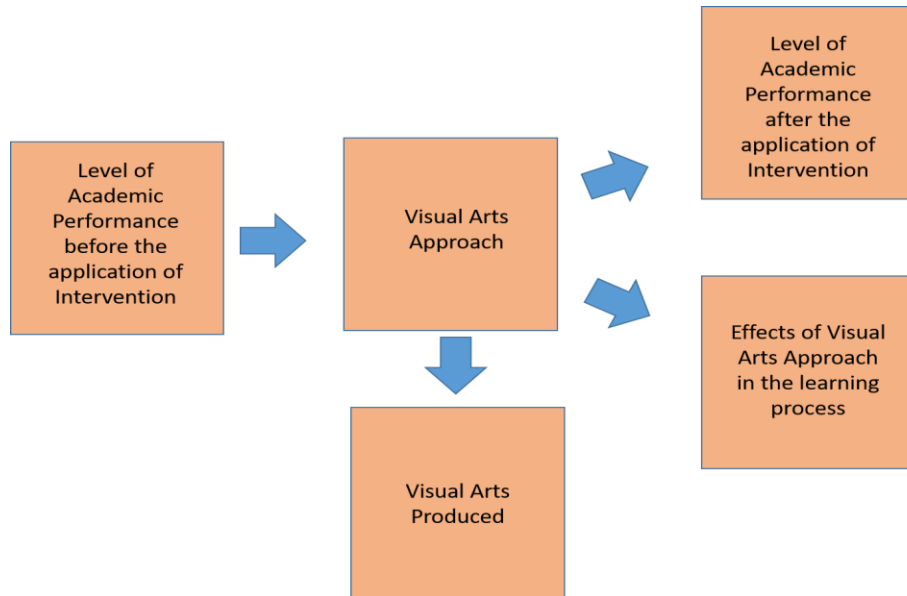


Figure 1. Paradigm of the Study

The figure presents the conceptual paradigm. After assessing the level of academic performance of the STE students before the application of intervention, Visual Arts Approach had implemented. During the application of the intervention, visual arts products were developed by the students through series of various activities. After the application of the intervention, the level of academic performance was assessed; and the effects are determined through structured interview.

II. METHODOLOGY

The study utilized a mixed-method action research design with assessment tests and structured interview guide as the main instruments in gathering the required data. There are thirty (30) STE students served as

participants and purposive sampling is implemented. The assessment tool was validated by science and technical specialists. There are two tools used in gathering data: first is the assessment tool composing of 100 items test questions; and second is structured interview guide composing of one question: What is the effect of Visual Arts Approach in the Learning Process?

III. RESULTS AND DISCUSSIONS

Student’s Level of Knowledge before the Intervention

The level of knowledge of STE students in Astronomy prior to the conduct of Visual Arts Approach was reflected by the result of their diagnostic/Pre-test.

The Pre-test was composed of forty (100) items. It was used in gathering information and identifying the strengths and weaknesses of STE students. It was administered to evaluate the level of students’ domain of learning. Class scores were described using frequency distribution and percentages.

Table 1 shows the frequency and percentage distribution of the respondents scores in 100 items pre-test given by the researcher. There are two (2) participants or 7% did not meet expectation. Twenty-two (22) participants or 73% of the class were Fairly Satisfactory. While, Six (6) or 20% were satisfactory. The overall mean is 40.4 with an standard deviation of 10.75. In summary, before the intervention of strategy, most of the students had fairly satisfactory level of knowledge and still need improvement.

According to the study of Balfour &Khonle (2016) revealed that misinterpretations remain at higher levels of education, and that the new knowledge may be integrated into their previous beliefs without a notable conceptual change.

Table 1. Frequency and Percentage Distribution of Participants’ Score in the Pre-test

SCORES	FREQUENCY	PERCENT	DESCRIPTIVE RATING
1.00 – 25. 49	2	7	Did Not Meet Expectation
25.50 – 50. 49	22	73	Fairly Satisfactory
50.50 – 75. 49	6	20	Satisfactory
TOTAL	100	100	
LEVEL OF KNOWLEDGE	SD = 10.47	Mean=40.4	Fairly Satisfactory

Student’s Level of Knowledge after the Intervention

The level of knowledge of STE students in Astronomy after the conduct of Visual Arts Approach was reflected by the result of their Post-test.

The Post-test was composed of forty (100) items. It was used in gathering information and identifying the strengths and weaknesses of STE students. It was administered to evaluate the level of students’ domain of learning. Class scores were described using frequency distribution and percentage.

Table 2 shows the frequency and percentage distribution of the respondents i scores in 100 items pre-test given by the researcher. There are Eleven (1) participants or 37% considered satisfactory. Nineteen (19) participants or 63% of the class were Outstanding. Overall mean is 79.6 with a standard deviation of 8.95. In summary, after the intervention of strategy, most of the students had outstanding level of knowledge.

Table 2. Frequency and Percentage Distribution of Participants’ Score in the Post-test

SCORES	FREQUENCY	PERCENT	DESCRIPTIVE RATING
50.50 – 75. 49	11	37	Satisfactory
75.50 - 100	19	63	Outstanding
TOTAL	100	100	
LEVEL OF COMPETENCY	SD= 8.95	Mean=79.6	Outstanding

According to the study of Buxner, Impey, Romine and Neiberding (2018) to be an educated consumer, one must have good foundation and evaluation ability towards science knowledge. The course introductory astronomy offers greater possibility to heighten the basic science knowledge and information literacy.

Significant Difference in the Student’s Level of Analysis before and after the Intervention.

To see the difference in level of knowledge of STE students taking astronomy discipline, pre-test and post-test were compared.

Table 3 shows the comparison of the mean and standard deviation of pre-test and post-test of control group.

Based on the table, the computed t-value is 38.27 significantly higher than the critical two tail value 2.05 with 29 degrees of freedom, there is enough evidence to reject the null hypothesis. It means there is significant difference on the scores of students in the pre-test and post-test of the participants and in the level of knowledge STE students after the application of the intervention.

It means that the intervention had positively affect and had a good response towards the students achievement based from their pre-test and post-test. The intervention deemed to be effective in assisting the students to learn using a unique and different mode in learning sciences.

Table 3. Significant Difference on the T-test of Pre-Test and Post-Test

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	40.4	79.6
Variance	119.5586207	82.86896552
Observations	30	30
Pearson Correlation	0.858730885	
Hypothesized Mean Difference	0	
df	29	
t Stat	-38.26994849	
P(T<=t) one-tail	1.11781E-26	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	2.23562E-26	
t Critical two-tail	2.045229642	

Visual Arts Produced

There are difference visual arts produced during the implementation of the intervention. These are as follows:

Painting. The produced visual arts where pigments of different colors are combined/ mixed and applied by different materials; brush, fingers, and pencils. Students painted galaxies, stars, planets etc.

Digital Art. The produced visual art where it was produced through the utilization of digital technology. Commonly used was photoshop and publisher to make, edit, customize a photo of celestial body based on their imagination.

Diorama. The produced visual arts was a 3 – dimensional miniature size model. Solar System and Earth’s layer we’re modelled.

Drawing. The produced visual arts where different instruments where used to draw in a paper a one or two dimensional model. Materials can be used are colored or lead pencil, graphite pencil, ballpen. Students draw Kepler’s planetary motion etc.

Effects of Visual Arts Approach in the Learning Process

Theme 1: Unleashing Creativity

Creativeness and visual art skills are truly important for a teacher. It gives liveliness and color to the teaching process. According to the study of Schlegel et. Al. (2015) “A group of undergraduate students who were given introductory painting or drawing lessons showed improved creative thinking, better ability to draw from observation and changes in the brain’s white matter compared to students who were taking introductory organic chemistry classes.”

A notable response mentioned that visual arts offers opportunity to improve creativeness.one participant (STES01) stated,

“Visual arts in astronomy affects my learning process because it gives an opportunity for me to improve my creativity and skills in making visual arts, even if I don’t have interest in drawing”

Generating creative ideas makes people do out-of-the-box solutions in any problems. A related statement was also said by one of the participant (STES08), “Applying visual art in astronomy helps me to improve my memory, concentration and art skills.” Unleashing creativeness improves the cognitive processes. It leads to growth towards innovation. Science Educators can also bring about change and innovation into the system, which goes outside the conventional ways and then improves over time (Rogayan&Dantic, 2021).

Taking risks for striving excellence are what top notch free thinkers with a creative learning mindset are doing. With constructive coaching, these learners may contribute solutions to the globe and create bridges to real life experiences through arts. (Morse, 2017).

Theme 2. Enhancing Visualization

According to Vermirovsky (2013) In astronomy, Visualization is a procedure of generating an imagery out of numerical and graphical form. It served as tool to hasten the comprehension of concepts. And based from actual experiences, STE students experienced that. One of the participant (STES17) stated that “Knowing that astronomy involves more of visual materials in learning, it helps learner to visualize the topics easily.” With images, especially if personally created, leads to thorough understanding and meaning of the context. A participant (STES02) also emphasized that visual arts in teaching is extremely helpful. “Visual arts approach in astronomy is very helpful because we were able to visualize the concept and gain a deeper understanding on it.” During the crafting, every single detail of the concept were deeply analyzed and synthesized on how it can be presented in the canvas. So, it justifies that visualization can be a bridge that connects the art and science (Sanual, 2013).

Theme 3. Understanding Made Easier.

According to Shabiralyaniet. Al. (2015) that appropriate visuals facilitates efficient learning environment. Having this environment, the development and personal understanding may be heightened in the gray areas of learning. Visuals helps us to easily understand concept because a huge part of the human’s brain is focused on visual processing. A human mind process visuals at superfast speed. And give a meaning in a very short time (Balm, 2014).

In relation to it, a participant (STES15) stated that “The experience of creating my own version of the concept using own art style greatly helps in understanding complicated ideas in astronomy.” A cliché says that “A picture tells a thousand words.” Every detail in the visual the students have crafted, gives them deeper meaning and enlighten the truth behind the context. It is true to every visual artists. It was experienced by a participant (STES07), “I’m a visual learner student. We have no chance to witness the celestial objects live. Some students, find hard to visualize everything just by their own thought or idea. So, visual arts in astronomy makes it easier for to know and understand every topic.” If artists are immersed in the crafting process, a deep appreciation towards the concept will be formed.

The utilization of visual representations are important practice among science fields. Through this, it paved way where communications and interactions among scientists been possibly easier and multiplied ways (Evagorou, Erduran&Mantyla, 2015).

Table 4. Effects of Visual Arts Approach in the Learning Process

Theme	Sample Significant Statement	Theme Description
1. Unleashing Creativity	Visual arts in astronomy affects my learning process because it gives an opportunity for me to improve my creativity and skills in making visual arts, even if I dont have interest in drawing. (STES01)	This focuses on the learners presents and maximize their creativities on the unfamiliar fields of visual arts towards sciences.
2. Enhancing Visualization	Knowing that astronomy involves more of visual materials in learning, it helps learner to visualize the topic easily. (STEST17)	This theme pertains how this approach push them to heighten their visualizations that greatly help them understanding the concepts.
3. Understanding made easier	The experience of creating my own version of the concept using own art style greatly helps in understanding complicated ideas in astronomy. (STES15)	This pertains how visual arts approach assists and boosts students’ understanding concepts.
4. Positively Affecting Metacognition	Visual arts approach can affect in our learning by how to interpret, criticize, and use visual information, and how to make choices based on the given output. (STES19)	This pertains the evolution of science learning, and touch the higher levels of cognitive taxonomy.
5. Learning Easily	Visual arts approach in astronomy affect my learning processing a way that it became easy for me to recall relevant things regarding to our	This pertains to the transformation of complexity to simplicity of learning astronomy concept.

	topic. (STES05)	
6. Memorizing Easily	Also, for the learners, focusing time on creating visual arts representing a certain topic on astronomy helps learners to remember the topic more easily. (STES17)	These theme suggests how visual arts approach offers enhancement towards memory cognitive process.
7. Developing Critical Thinking	It is very challenging for me because I'm not that good in visual arts. But with this, it made me think critically due countless visualization on how to present the astronomy topic through visual arts. (STES16)	This focuses on how the process of art crafting be related to critical thinking.

Theme 4. Positively Affecting Metacognition

According to Moore (2013) stated that through arts, cognitive strategies may be efficiently implemented which offers opportunity for learners to assimilate and exhibit they indeed learn. A notable response from one of the participants (STES19) stated that, “Visual arts approach can affect in our learning by how to interpret, criticize, and use visual information, and how to make choices based on the given output.” Related response was also stated, “Through visual arts, my cognition on a certain topic was enhanced. Using sketch pads and other art materials, I recreated different concepts of astronomy which helped me in mastering them unto a higher level (STES20).

With the findings of Goldberg (2005) it revealed that throughout the entire art making process, metacognition were used by every students. Because, if art served as representation of learning, then their thinking should manifest in the art form (Moore, 2013).

Theme 5: Learning Easily

One of the effects visual arts approach is that making learning easier. According to Khan (2017) that learning is directly related to arts and crafts. Visual arts achievement affects students’ academics. The more a learner gives effort to something, the more benefits they may gain from it, sense of appreciation, realization and achievement. By feeling all these, it means that individual has learned. A participant (STES05) that this approach positively affects them, “Visual arts approach in astronomy affects my learning process in a way that it became easy for me to recall relevant things regarding to our topic.” Many things may experience during the crafting process of visual arts. Just the thought on how celestial phenomena or space events be presented in a creative manner using specific medium may push them to study eagerly. For example, they created a diorama of the space explorations, they research more, study every details, conceptualize it, analyze and synthesize every component of the diorama and lastly execute the crafting process. During that time, they have experienced in many stages that made them learn more than the textual information. The same statement was reiterated by most of the respondents. “As a Visual Learner, I’ll be able to make learning easier. (STES03)” It is evident that, if visual arts skills improve that learning skills also improve. They are more suitable at adapting skills and so they learn faster than the non-visual artists (Khan, 2017).

Theme 6. Memorizing Easily

According to the study of Bushman (2012) it revealed that it is easier to retrieve and remember information through the help of visual cues. When a learner make an effort to put into an art work, it will make an imprint into their minds. A person who constantly working and thinking on a certain project may not easily forget the details and the process. Therefore, with visual arts, the memorization of the students towards the topic greatly increases. One participant (STES17) revealed about it, “Also, for the learners, focusing time on creating visual arts representing a certain topic on astronomy helps learners to remember the topic more easily.” When the students working on their craft for astronomy, they researched, review, analyzed and synthesize each information to have a precise conceptualization when they put it into art. So every details will have a deep impression about them, that may create every detail a certain visuals about it for them to easily remember. Another participant (STES11) emphasized it, “When I am working with my activities, in the long time, I unconsciously make a mental picture out of it. So, whenever that picture crosses into my mind I easily remember the concept in astronomy.” Words are abstract. It was also proven, that the learners exerts effort to create visual associations have better recall (Bushman, 2012).

Theme 7. Developing Critical Thinking

According to Uddin, Shimizu & Widiyatmoko (2019) that in this age of science and technology society, learners must have possessed the 21st century skills, especially critical thinking skills. A study of Nusbaum & Silvia (2011) revealed that an individual had high fluid reasoning, an idea connected to critical thinking, are better in generating creative ideas, and can gain more from strategies that encourage creative thinking. Like a participant said,

“Through visual arts, the lessons been inculcated in my mind. The images last on my mind longer than texts.” STES13 and another said “It is very challenging for me because I’m not that good in visual arts. But with this, it made me think critically due countless visualization on how to present the astronomy topic through visual arts.” STES16.

IV. CONCLUSIONS

1. The level of knowledge of STE before the application of intervention is fairly satisfactory and still needs improvement.
2. The level of knowledge of STE students after the application of intervention is outstanding.
3. There is a significant difference between the pre-test and post-test of the STE students.
4. There various forms of visual arts were produced after the application of intervention, these includes; Painting, Digital Art, Diorama and Drawing.

From the thematic answers of the students, there seven (7) themes emerged, these includes: (a)Unleashing Creativity; (b) Enhancing Visualization; (c) Understanding Made Easier; (d) Positively Affecting Metacognition; (e) Learning Easily; (f) Memorizing Easily; and (g) Developing Critical Thinking.

V. RECOMMENDATIONS

1. Implement visual arts approach in Astronomy discipline as intervention.
2. Develop and explore more forms of visual arts approach that can be implemented in the course.
3. Utilize the intervention to make the concepts in astronomy be more easier to understand.
4. Further studies may be conducted to validate the results of the study and to discover other variables which can improve and be observed in implementing the Visual Arts Approach across different fields of sciences, especially astronomy.

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REFERENCES

- [1]. Balfour, J. and Khonle, A. (2016) Testing conceptual understanding in introductory Astronomy. *New Directions in the Teaching of Physical Sciences*. DOI: 10.29311/ndtps.v0i6.375
- [2]. Balm, J. (2014) The power of pictures. How we can use images to promote and communicate science. *BioMed Central*. <http://blogs.biomedcentral.com/bmcblog/2014/08/11/the-power-of-pictures-how-we-can-use-images-to-promote-and-communicate-science/>
- [3]. Bushman, B. J. (2012) Learning through visuals: visual imagery in the classroom. *Psychology Today*. <https://www.psychologytoday.com/us/blog/get-psyched/201207/learning-through-visuals#:~:text=A%20large%20body%20of%20research>,
- [4]. Buxner, S. R., Impey, C. D., Romine, J. and Neiberding, M. (2018) Linking introductory astronomy students’ basic knowledge, beliefs, attitudes, sources of information and information literacy. *Physical Review Physics Education Research*. DOI:10.1103/PhysRevPhysEducRes.14.010004
- [5]. Canlas, I. P. (2013) University students' understanding on selected Astronomy concepts. *Sanhiram Multidisciplinary Journal*. https://www.researchgate.net/publication/317713432_University_Students%27_Understanding_on_Selected_Astronomy_Concepts
- [6]. De Greve, J. P. (2009) Challenges in Astronomy Education. *International Astronomical Union. Highlights of Astronomy, Volume 15*. Retrieved from doi:10.1017/S1743921310010884
- [7]. Evagorou, M., Erduran, S. & Mäntylä, T. (2015) The role of visual representations in scientific practices: from conceptual understanding and knowledge generation to ‘seeing’ how science works. *IJ STEM Ed* 2, 11. DOI: <https://doi.org/10.1186/s40594-015-0024-x>
- [8]. Garcia, B. (2009) Education of Astronomy in Argentina: a global vision and the study of special cases of no-formal education. *International Astronomical Union. Highlights of Astronomy, Volume 15*. https://www.researchgate.net/publication/231853397_Challenges_in_Astronomy_Education

- [9]. Goldberg, P. (2005). Metacognition and art production as problem solving: a study of third grade students. *Visual Arts Research*, 31(2), 67-75. JSOTR. www.jstor.org/stable/20715385
- [10]. Khan, A. (2017) Importance of Visual Arts Education at Schools. Jagran Josh. <https://www.jagranjosh.com/articles/improtance-of-visual-art-education-at-schools-1504507904->
- [11]. Moore, D. (2013) Teaching Students to Know How they Know: Metacognition through Arts. Institute for Arts Integration and STEAM. <https://educationcloset.com/2013/10/09/teaching-students-know-know-metacognition-arts/>
- [12]. Morse, K. (2017) Developing creative thinking skills through arts. National Association for Gifted Children. <https://www.nagc.org/blog/developing-creative-thinking-skills-through-art>
- [13]. Needle, A. et. Al. (2007) Combining art and science in “Arts and Sciences” education. Research Gate. Retrieved March 27, 2020 from 10.3200/CTCH.55.3.114-120
- [14]. Nusbaum, E. C. & Silvia, P. J. (2011) Are intelligence and creativity really so different? Fluid intelligence, executive processes, and strategy use in divergent thinking. Elsevier Volume 39, Issue 1. Retrieved from <https://doi.org/10.1016/j.intell.2010.11.002>
- [15]. Punzalan, J. F. (2018) The impact of visual arts in student’s academic performance. Vol. 6 No. 7 July 2018. International Journal for Education and Research. Retrieved March 21, 2020 from <https://ijern.com/journal/2018/July-2018/10.pdf>
- [16]. R.A. 7722 entitled “AN ACT OF CREATING THE COMMISSION OF HIGHER EDUCATION, APPROPRIATING FUNDS THEREFOR AND FOR OTHER PURPOSES OF”. Retreved March 27, 2020 from https://lawphil.net/statutes/repacts/ra1994/ra_7722_1994.html.
- [17]. Rogayan, D. and Dantic, M. J. (2021) Backliners: Roles of science educators in the post-COVID milieu. *Aquademia*, 5(2), ep21010. DOI: <https://doi.org/10.21601/aquademia/11053>
- [18]. Shabiralyani, G. et. Al. (2015) Impacts of visual aids in enhancing the learning process case research: District Dera Ghazi Khan. Journal of Education and Practice. Retrieved April 6, 2020 from <https://files.eric.ed.gov/fulltext/EJ1079541.pdf>
- [19]. Trumper, R. (2000) University students’ conceptions of Basic Astronomy Concepts Physical Education. IOP Science. DOI:10.1088/0031-9120/35/1/301.
- [20]. Uddin, M. R., Shimzu, K. and Widiyatmoko, A. (2020) Assesing secondary level students’ critical thinking skills: inspiring environmental education for achieving sustainable development goals. Journal of Physics: Conference Series. DOI:10.1088/1742-6596/1567/2/022043
- [21]. Vermirovsky, J. (2013) Importance of visualization in education. Semantic Scholar. <https://www.semanticscholar.org/paper/The-Importance-of-Visualisation-in-Education-Veřmiřovský/e842910739378494964aecbcb71e56558b91bbfd>