



Ethno-Science and Physics: Unveiling Historical Ingenuity for Modern Andragogy at Undergraduate Level in Odisha

Ishita Mishra¹, Swagatika Meher², Varun Ashokan³ and Dipanshu Sharma⁴

¹Department of Education RIE (NCERT) Bhubaneswar. E-mail: kukumuku97@gmail.com

²Department of Education RIE (NCERT) Bhubaneswar. E-mail: swagatikameher75@gmail.com

³Assistant Professor, Department of Education, RIE (NCERT) Bhubaneswar, Email Id: varunnkal@gmail.com

⁴Assistant Professor, Department of Education, RIE (NCERT) Bhubaneswar,

E-mail: drdipanshusharma@gmail.com; <https://orcid.org/0009-0007-9920-0166?lang=en>

To Cite this Article

Ishita Mishra, Swagatika Meher, Varun Ashokan & Dipanshu Sharma (2025). Ethno-Science and Physics: Unveiling Historical Ingenuity for Modern Andragogy at Undergraduate Level in Odisha. *Journal of Contemporary South Asia*, 1: 1, pp. 71-93.

Abstract: This article gives a theoretical scaffolding for changing history andragogy at the undergraduate level in Odisha by blending physics, history, and ethno-science. It investigates the possibilities of including emergent technologies in effective interdisciplinary teaching. The classroom should shift from passive memorization to active inquiry-based learning. The main argument is that Odisha's cultural practices and tangible heritage are repositories of local wisdom which based on scientific principles which were aimed at the good of the community. Through in-depth case-studies of Konark sun temple, Puri Jagannath Temple, traditional weaving, ancient maritime heritage of Odisha, pottery, and traditional water conservation systems. This paper throws light on the implementation of principles of applied physics in the local wisdom of Odisha such as rotational mechanics, thermodynamics, fluid dynamics and acoustics. By using ethno-science to teach history students will easily form associations between their tangible cultural heritage and physics. The use of emergent technologies like virtual reality (VR), augmented reality (AR), Mixed reality (MR) and Artificial intelligence (AI) is a catalyst for learning experiences that encourage critical thinking skills. This model is welcomed to do away with rote memorization as per the guidelines of NEP 2020. The paper concludes by mentioning suggestions for an interdisciplinary curriculum design.

Keywords: ethno-science, history pedagogy, Indigenous knowledge, interdisciplinary curriculum, multidisciplinary curriculum, physics education, tangible heritage, Tertiary education

Introduction

“The true goal of the education is to connect the head with the heart, and the abstract with the concrete.”

—Sir Ken Robinson

The 21st century demands for teaching methods that go beyond the normal water tight compartmentalizing of disciplines. This paper investigates the relation of the principles and laws of physics with ethno-science. This demonstrates how ancient practices in Odisha have incorporated the complex scientific insights. Ethno-science is a multidisciplinary domain that acts as a critical connection between scientific learning and social conventions. A core principle of ethno-science is to elevate local knowledge to ensure its recognition. This gives a rational basis for our age-old practices which otherwise would have been mired in superstitions. Ethno-science makes the abstruse concepts of physics come alive in front of laymen. This approach is important for weaning the science education from the clutches of colonialism and neocolonialism [1] [2] [3]. It validates local knowledge as a genuine form of scientific enquiry where learners move away from western centric view of cultural history. Physics as the king of sciences gives a systematic structure for comprehending the principles which control energy, matter, and their transmutations in the universe [4]. The evolution of physics shows that empirical observations are described by core tenets with noteworthy phenomena linking to intense conceptual understandings. Conventional practices leverage these physics principles implicitly or explicitly [5]. Ethno-science-based teaching learning at undergraduate level improves learners’ critical thinking skills in both physics as well as history. This andragogical strategy equip rational thinking by strengthening the theoretical framework in students’ vicinity and cultural viewpoints [6]. Any concept gets more deeply ingrained in ones’ mind when it is directly correlated with daily life and local wisdom. The development of logical thinking skills is identified as a much needed 21st century competency for traversing through intricate global challenges [7]. In ethno-science-based andragogy real-world issues are presented that require a strict evaluation of facts, a collation of several solutions followed by the generation of sound decisions. When challenging physics concepts are exhibited through well-known cultural practices such as traditional games or handicrafts preparation learning turns into an active meaning making process [8]. The abstract concepts of physics are given a tangible form which can be easily related thereby

enhancing student motivation. The inclusion of culturally responsive content can boost the learning outcomes and pave way for in depth understanding. this paper advocates transforming history pedagogy in Odisha [9]. Odisha has a rich tradition of sculpture, art and craft, architecture where scientific principles and laws are embedded in the techniques, processes and materials used. School of Indigenous knowledge, Science, and technology at KISS, deemed to be university in Odisha is involved in protection of local knowledge systems. This initiative has shown as to how Odisha's heritage can be incorporated into formal education system.

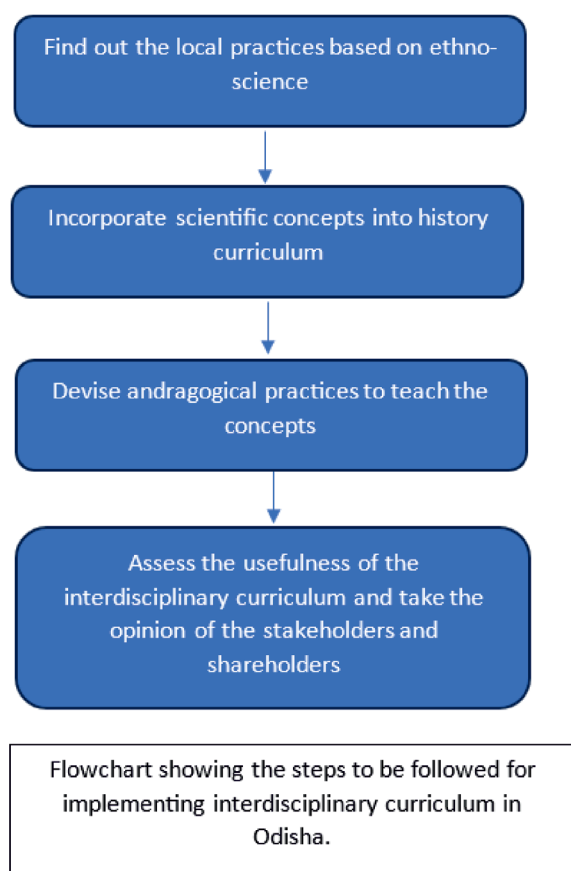


Figure 1

Figure 1 shows a flowchart that depicts the procedure to be followed by the policymakers to implement interdisciplinary curriculum in undergraduate level as per the guidelines of NEP 2020.

Principles of Adult Learning

The global educational landscape in Odisha is important for contextualization of learning in ways that are rooted in the indigenous knowledge and local wisdom. When history and ethno science are taught using scientific andragogical method it will make learning more relevant and transformative [10]. Malcolm Knowles popularized andragogy which is the practice of teaching mature learner. Contrary to pedagogy which emphasizes on children and Adolescent learning Andragogy focuses on the particular needs, motivation and characteristics of Adult learner. Under graduate students especially in underserved areas may be first generation learner or job holders who can benefit from a teaching approach which respects their autonomy and previous experience [11]. Andragogy is based on 5 core principles which are experience, readiness to learn, self concept, orientation to learning and motivation to learn.

- 1. Experience:** The youths see themselves as autonomous learners who like to regulate their learning on their own terms. They prefer that their educators bring a deep set of life experiences to the class. This involvement of student in hands on learning is a priceless resource in the teaching learning process. The rural students can share their encounter with traditional technologies like weaving, irrigation method, and construction of houses. This can be utilized in demonstrating complex physical theories in culturally grounded method that will be meaningful to each learner [12].
- 2. Readiness to learn:** Mature Individuals are more inclined to learn concepts which have practical use in their carrier. By including ethno science into school curriculum professors can show how indigenous knowledge system corresponds to ethno scientific principles enriching student's contextual understanding and common sense.
- 3. Self Concept:** Grownups see themselves as self directed and self motivated students. They lean toward teaching style that gives ample space for autonomy and provides curretted import into how they learn and how to apply it in their lives. A syllabus that consists of Indian heritage and ethno scientific content equips learners to engage with science and heritage through familiar Socio cultural lens [13].
- 4. Orientation to learning:** The adult learners show a preference to solve real world problems which can serve them immediately. This is diametrically

opposite to the school going children who usually learn for future application of conception theory. The mature learners are interested in finding out how knowledge can help them now. This is pragmatic in nature where the learners are not drawn towards mastering the content for its own sake. Here focus is shifted from content centered to problem centered. Problem centered approaches can incorporate scenario analysis, practical assignment and project based learning.

5. **Motivation to learn:** Kids are driven by external rewards (approval, parental expectation, and grade). Whereas adults are often stimulated by internal factors namely carrier satisfaction, self esteem, quality of life and autonomy. Impactful adult education programme and college teaching support this internal motivation factor. In colleges learner should be given autonomy in selection of specialization, choosing real life projects and going for student exchange programmes which are well suited for psychological mean for competence and purpose amongst the youngsters. Moreover these internal motivators are functional in sustaining long term engagement.

Ethnoscience in Global Arena

Ethno science Consist of the body of indigenous knowledge that communities develop about nature and their traditional practices which incorporates ecological relationship, Engineering principles, medicinal plants, and religious customs with their profound scientific insight [6] [14]. About 16.22% of the research publications feature global collaboration reflecting a rising interest of the academia in this field. USA, Indonesia, Brazil have strong citation impact when it comes to ethno scientific based researches. Themes are primarily centered on scientific literacy, health application, protection of indigenous knowledge and tourism [15]. In Brazil ethnoscience- particularly ethnoecology and ethno biology – has emerged as a rapidly growing domain for research. Propelled by indigenous knowledge revitalization and bio diversity conservation, communities and academics are intersecting to foster socio ecological conservation method [16]. In Indonesia scholars are exploring how ethno science – indigenous plant knowledge, traditional games and herbal remedies (*Jamu*)- can be incorporated in tertiary education to form linkages amongst sustainable economic development, culture and technology [17]. In Europe the European network of ethno biologists (ENE) connects more than 100 researchers encouraging interdisciplinary collaborations. It emphasizes “Ethics of care” where focus is on co-created knowledge with local communities

and solving modern social challenge and environmental degradation [18]. In India Santhal community are famous for their environmental perception through folk cognitive structure- Including mythology, emotional attachment, resource distribution and inter generational understanding [13]. Initiatives like the Aaple Pathardi Community network in Maharashtra have met a o[pen source digital platform- including text, video, audio and e commerce portal – to preserve and disseminate indigenous agro biodiversity knowledge which can help in livelihood generation for vulnerable tribal communities. In Indonesia ethnosience has become a part of national curriculum (“KURIKULUM MERDEKA”) since 2022 which has foster interdisciplinary science education and social sciences education [17]. Indonesia produced 355 publications centered on ethno science from 2014-2023. However, India has not given a formal status to ethno- science in mainstream curriculum which is a matter of concern.

Konark Sun Temple

The Konark Sun Temple (1250 CE) is an architectural masterpiece. This monument was designed asa gigantic chariot to the allocated to the sun god. Its design encompasses 24 carved stone wheels, each of which is about 12 feet in diameter with 8 spokes. This represents the 12 months of the Odia calendar (divided into 2 cycles) [19]. The beautifully carved wheels of the monument functions as a sundial. The chariot is pulled by seven horses which signify the seven metres of Sanskrit prosody. The ground plan of the temple is aligned to the traditional principles of construction as mentioned in the Silpasarini [20]. The erection of this temple consisted of three types of stones: laterite, chlorite and Khondalite which were chosen keep in mind the weather resistant and heat retaining capabilities. During summers these stones reflected less heat that kept the interior cool [21]. the temple was oriented eastwards, ensuring that the first rays of the sun would fall at the main entrance. As per the legends there used to be a huge 52-ton lodestone at the temple’s superstructure (Dadhi Nauti) where the iron content idol of the sun god used to float in the air due to its magnetic properties. The magnetic field supported the temple structure to make it stable. The stability was ensured by balancing the huge iron beam through magnetic force. The iron beams used in the Black pagoda showcase the metallurgical knowledge of Odia craftsman which had phosphorous content, This Phosphorous content was responsible for making a protective coating around the iron beams. This idol used to disturb ship compasses that sailed along the coast.

This temple had curved stairs which were meant to prevent the destruction from earthquake. The temple was designed with such exactness that one could hear the ocean from inside of the temple though the sea was quite far away [22]. The Nata Mandir of Konark temple was formulated with a unique angle and stone surface that amplified musical performance and made it easier for the sound to travel smoothly. The ability of absorption of sound was influenced by the curvature and material density. The temple structure follows a ratio of 1:2:4 and 3:4:5 triangles as mentioned in Vastu Shastra [23]. Indigenous knowledge systems can teach students the use of science for the good of the humanity.

Puri Jagannath Temple

The Jagannath Temple Located in Shri kshetra, Puri is one of the sacred char Dham of India. This temple is dedicated to the worship of lord Jagannath. This temple is a marvel in terms of architecture and phenomena. This temple was built by king Anantavarma Chodaganga Deva, in 12th century CE. The main Dome (Shikhara) has been observed to never cast the shadow at any time of the day. This Unique Phenomena is unexplained by Modern Science. Experts have speculated that the Temple's Architectural Design has been the reason of the shadow either falling on itself or Diffusing in a manner that it is not visible through naked eyes [24]. This is a unique phenomenon where rules of optics and geometry are broken. There is another surprising feature of Puri temple in relation to Aerodynamics. Usually, it is seen that in nature wind blows from sea-ocean to the dry land during the day and from land to sea at night [25]. However, in the proximity of Jagannath temple the reverse is true. As per the Modern-science, such a phenomenon is opposite to the basic coastal wind pattern. Till Today it has not been explained with convincing proof. The devout hold a belief that temples spiritual era, The sole cause for the reversal of Nature's law. Mahaprasad that is the Holy rice offering is cooked in seven pots which are tacked on top of each other. As per common sense one will say that the pot at the bottom will get heated first, but in Sri Jagannath temple we see that the top most pot is cooked first instead of the pot at the bottom. This unexplained phenomenon breaks the rule of Thermal engineering. One of the possible reasons for this could be that steam pressure and sealed pot design may lead to reverse heat distribution [26]. The temple kitchen is an ancient model of zero waste community kitchen based on the principles of Eco-friendly resource management. There is another miracle associated with the temple kitchen. Regardless of the numbers of

the devotees visit the food is always sufficient- It never falls sort and never wasted. The flag at the top of the temple's main dome moves against the direction of the wind but till today there is no concrete explanation for this, we can assume that this miracle happens due to Temple structure or Air Vortices which may change the direction of the wind flow. There is a tradition in Shree Jagannath temple where by a priest is supposed to climb 250 feet to replace the flag daily with no safety gear, even during storms and cyclones. The flag must be changed. The reason being that if the flag remains unchanged even for one day, then the temple will be closed for the next 18years. There is a nonpareil related to the temple in which no planes or birds are seen flying above the Jagannath temple, three theories have been given to answer these phenomena. One of them is that the Birds try to avoid unique air currents. Second Theory says that a strong magnetic field surrounds the temple, which makes it impossible for the birds to pass by that area. The third theory says that High Frequency sound vibrations from the divine rituals performed in the temple discourage birds from coming near the structure. The inner sanctum of puri temple is silent even if there are large crowds or any celebrations. As per the principals of Acoustics the formidable stone walls and dome design scatter sound or absorb. This is an amazing illustration of Acoustic engineering. The temple appears to be at the same distance and height, no matter how far you walk or where you are in Puri. This phenomenon has been attributed to the vertical design and uniform costal landscape, making an uncommon optical illusion. The temple has been designed in such a manner that sun rays fall directly on the faces of deities at determined times of the year. Neela Chakra (Blue Wheel) upon the temple is observable from any place in puri, this has been attributed to the genius of the Odia Architect who were masters of celestial Engineering.

The Puri Ratha Yatra

The joyous Puri Ratha yatra is a festival where colossal chariots are pulled by thousands of devotees. Each chariots weighs more than forty tons. These Chariots are assembled using thousands of logs of twelve different species. Around 4000 different pieces of wood are used in erecting the chariots. In earlier times these chariots did not have a working brake system which caused safety hazards as they used to role forward by 96-120 inches, even when several devotees tried hard to stop them. A much-needed innovation was brought in by Ashwin Kumar Mishra who configured a special break mechanism. This brake system, made of rubber straps

and Sal wood logs, is lowered through a chain and pulley setup to stop the chariots without causing any damage to the wheels. The rubber which has been used in the break mechanism is crucial for its shock absorbing property and durability. This provides a real-world instance of applied physics, related to energy, friction, and force. We can see that traditional practices and ancient knowledge can evolve into a safer society through the implementation of modern engineering principles. The Ratha yatra offers a case study for teaching the interaction of applied physics in our tangible heritage [24].

Ancient Water Harvesting System

Odisha has a long-standing history of Water harvesting and conservation, wherein age-old practices play a seminal role in mitigating droughts and famines since time immemorial. The ancient kingdom of Odisha used systems like Bandhas, Katas, and Mundas as irrigation sources [27]. These water conservation systems were constructed through mighty earthen embankments across the Natural Drainage channels to store water. These systems leveraged the natural slope of the area to channel water from Natural fresh water sources into manmade tanks. They embedded features like steps with curved wall and sealed settling tanks to reduce the speed of water, preventing soil erosion and upgrade water quality. These water tanks allowed water to percolate into the ground which led to recharge of ground water tables [28] [29]. Many benefits were observed due to this practice such as minimize silting of rivers, reduced soil erosion, and increasing green cover. The impact of these practices was seen in control of floods and reduction in run off. *Pemghara* in Odisha have shown the effectiveness in capturing rain water and the consequent improvement in ground water tables. The traditional Water harvesting system of Odisha reveal an astute understanding of Fluid Dynamics, Geosciences, and hydrology. The design of *Katas* Manage water flow which show a good understanding of Fluid Mechanics and Gravity. The silt settling tank demonstrate and awareness of our ancestors are of sedimentation principle [18] [30]. The emphasis on recharge of ground water aquifers through percolation underscores an in-depth understanding of hydrogeology. Our Ancestors applied principles of physics in water conservation for community resilience and ecological balance. They also highlight the understanding of hydrostatics and environmental physics showing how sustainable practices were applied in antiquity to fulfilled the need of society [31].

Pottery

The potter community (*Kumhar or kumbhar*) in Puri's *Kumbharapada* has made utensils for Maha Prasad since the 12th century. Their Pottery serves spiritual functions as well as everyday rituals in temples of Odisha namely, Lingaraj Mandir, Ananta Vasudev Temple and Puri Jagannath Temple [32]. Every meal at Jagannath Temple is made using fresh earthen ware. Pots are never reused. This is done to guarantee neutral chemical interaction and hygienic spiritual purity. The rice in this pot can serve approximately 10-12 people [33]. This can be scaled up across 175 hearths to feed around 17500 people in only 15 minutes. This logistical marvel demands High Thermal efficiency and heat distribution. The archaeological excavation in Odisha has shown pottery fragments of 4th century BCE to 14th century CE. Red ware and Black-Red-ware, slipped ware highlight the sophisticated firing methods and urbanisation in the ancient times. The excavated pots have proved that our ancestors were well versed in Burnishing fast wheel production and oxygen control during firing of pots, which implies they understood Thermodynamics and Material Science. Barapali Village in Bargarh district is famous for Terracotta Roof styles (*Khappara*) cast with motifs of animals which are believed to bring good fortune. Manbodha Rana is a famous Artisan who makes such unique roof tiles. The *Khappara* tiles are made from clay and fired to sculpt it into durable hexagonal forms. These shapes use structural mechanics with dense edges strengthening the form, distributing load and stress to achieve weather resistant quality through controlled firing. The functioning of Potter's wheel is a practical application of rotational mechanics. The wheel spins because of Centripetal acceleration, that is determined by its diameter and the potters-controlled velocity ($a = v^2/r$). When the wheel rotates, the lump of clay undergoes centrifugal force and outward tendency which the Potter must counteract by applying inward force with their bare hands [9] [14] [34]. Centring the clay a seminal step because the outer rim of the wheel spins weaker than the centre, thereby making of centre clay more exposed to centrifugal force. Friction is another essential force [4]. Potters keep the clay wet to lower the coefficient of Friction ($F_f = \mu N$) between their hands on the clay, enabling easier shaping notwithstanding the high normal force required. The Ethnophysics in pottery indicates a highly intuitive knowledge incorporated in Artisanal craft. The potters have mastered the concept of physics without studying formal formula. The craft of pottery shows balance of moisture and control of kiln atmosphere which highlights the age-old iterative science [19] [35]. Pottery uses the following principles of Physics- Fluid mechanics, heat transfer, Structural engineering, materials transformation.

Weaving

Odisha is famous for its remarkable silk ikat weaves, a skill where warp and weft threads are carefully tie -dyed prior to weaving elaborate patterns on the loom [36]. The process of weaving calls for the inter twining of two sets of threads- the weft (Transverse) and the warp (Longitudinal) at right angles on a loom. Loom mechanisms are classified into primary, secondary and auxiliary motions. Primary motions consist of shading, picking and beat up. Shading involves separation of warp threads to make a space for the weft [37] [24]. In Picking the Shuttle is propelled which carries the weft across the loom. In Beat up the newly inserted weft thread is lead firmly against the earlier woven fabric. Secondary motions are let-off and take-off. In Let-off the warp threads are released at a predetermined rate. In Take-off the woven fabric is winded [16]. The primary and secondary motions are important for maintaining a harmonious warp tension and fabric density during the weaving process. Conventional handloom, engaged direct application of Tension, Force and Rhythmic motion, even if the production rates were low [22] [33] [38]. The process of weaving is a complex application of mechanical principles. The loom works as a sophisticated machine, displaying principles of force, tension, and motion. Shadding necessities a meticulous manipulation of threads to create an opening, picking is the use of kinetic energy to move the shuttle, and beat up required mechanical action topack down the weave, shaping fabric density [26] [39] [15]. The Secondary Motions are useful for ensuring a uniform tension and fabric density. From the above mention facts, we can infer that our weavers (*Bunakars*) have developed and innate understanding of strain, stress, and material properties under tension. The complex mechanical system of handloom was refined over generations through evolutionary design and observed results, leading to the production of durable and ornate design. Some of the Traditional textiles of Odisha that are woven using handloom – *Sambalpuri Ikat (Bandha)*, *Khandua Pata*, *Bomkai Saree*, *Kotpad Handloom*, *Habaspuri Saree*. In Sambalpuri fabric *Pasapalli* (checkerboard) motives emerges through colour symmetry and 2D periodic tiling which are related to Optics.

Maritime Heritage of Odisha

Odisha is renowned for having a glorious maritime legacy marked by cultural exchange trade and expeditions across the Bay of Bengel to south east Asia. This maritime tradition is honoured during the *Boita Bandana* Festival, where people float miniature boats in water bodies to pay respects to there ancestors who went

on dangerous voyages [27] [40] [41]. Behind these age-old customs lies a gamut of Ethnoscience knowledge of navigation, weather, ships, and sea. This indigenous knowledge has been transmitted orally among communities like *sadhabas*, whose ancestors used to be the ancient mariners of *kalinga*. Boat makers chose special types of boats for example Tik and Sal based on its ability to float and its durability. Conventional boats like *Boitas* were prepared without using any blueprints. They were designed solely on inherent knowledge [42]. As per Archimedes Principle the Boats tend to float due to the weight of water displaced being same as the weight of the boat. The principles of Buoyancy and density were kept in mind before choosing the wood for constructing boats. Usually, woods with density lesser than water 1000kg/m^3 were chosen because wood that are less dense float better. The Hulls of these boats were designed to maintain a low centre of gravity which will prevent the boat from capsizing [36] [43]. The mariners utilized bamboo masts and cloth sails to seize the wind direction and maintained speed. Sails used to be calibrated manually based on wind patterns to augment movement. As per Newtons third law ($F(A \text{ on } B) = -F(B \text{ on } A)$) air Shove against the sail which causes the sails to push back there by propelling the boat forward. Using the principle of Bernoulli the Sail work similarly like air foils to create motion and lift. The principle of vector force mechanics is also applied in Sailing. Wind force used to be split into side ways drift and forward motion, which was compensated by sailor using Sail angles and rudders. The mariners of Ancient Odisha could navigate in the deep sea without any instruments. The sailors used the position of moon, sun, stars, and waves for navigation [30] [29] [18]. Cloud types, sea colour and Bird flight were utilised as cues to evaluate distance to land. Variations in sea colour would happen due to scattering of light that aided in accurate estimation of land proximity and ocean depth. The ships were designed to remain stable during storms in sea. The boats were constructed with low profile hulls and wider bases to withstand wind and high tides. The captain ensures that cargo was placed in such a manner as to ensure the stability of the boat. Balanced cargo decreased unasked for torque ($\tau = rF\sin\theta$) that could threatened to capsize the boat (Bhattacharya & Sahoo 2022). To keep the movement of inertia under balanced the cargo was distributed in such a manner that it resists a perching and rolling. The ship builder had designed the ship to reduce energy loss and resistance due to friction caused by drag force and wave resistance [23] [44] [41]. The sailors used drums and conch shells (Sankha) to send messages and signal positions during darkness or fog. The builder of the boats used lime natural

resins and fish oil for water proofing the boats. Resins decrease Water permeability because of their hydrophobic molecular structure. Woven Coir (Coconut Fibre) was used to bind different parts of boats. Mariners usually timed their sea voyages with tides which they forecasted using lunar phases. New moon and full moon are considered important for low and high tides. Our ancestors knew about the periodic tidal bulges caused due to the gravitational pull of the sun and the moon [28]. The tidal movement follows foreseeable patterns grounded on gravitational oscillation and wave mechanics. The monsoon wind cycles and ocean current are also kept in mind while planning for the journey. The ancient sailors used to go on long distance sea travel to Myanmar, Sri Lanka, Bali, java, and Sumatra [13] [3] [36].

Traditional Cooling Methods of Odisha

The country side of Odisha and the Tribal areas like Mayurbhanj and Koraput make their houses using cow dung, straw and mud, which are also known as *Matighara* (Mud Houses). These natural materials keep the house warm in winter and cool during summer seasons. The thick mud walls tend to absorb heat at a slow pace during day and release the heat at night due to thermal mass effect. The principle of evaporative cooling makes the moisture in the mud evaporate slowly, which ends up absorbing heat from surroundings. Straw and mud are bad conductors of heat. Due to low thermal conductivity of this material the heat transfer is slow from outside to inside [45] [36]. Thatched roof (Khapara ghara) is used to provide roofing to rural houses Thatched roofs are made of coconut fronds or palm leaves and dried paddy straw. The sloped design of thatched roof reduces heat build up and simultaneously increases air flow. The straw layers used in these roofs provide insulation by trapping air which reduces conduction of heat. The straw undergoes radiative cooling where it reflects some amount of solar radiation consequently reducing absorption. The traditional homes in odisha have an open central Courtyard design (Angan) surrounded by living spaces. The rooms around the courtyard act as shaded balls which remain cooler due to reduced impact of sunlight. The phenomena of convection current is seen as hot air rises from the open central space and escapes, bringing in cool air from shaded areas. Khus-khus (vetiver) screens or wet jute mats are used at homes in doorways or windows to keep the house cool. The science behind it is that when wind passes through damp fibres it leads to evaporation of water and cool air comes into the house. There is an exchange of heat when the evaporation process subsumes heat from the air. Earthen pots for cooling of water

(*Matka*) are commonly used in Odisha to keep portable water refreshing and cool in summer. This phenomenon again employs the phenomena of cooling. Water goes through the small pores in the pot and evaporates from the exterior, soaking in latent heat from the water inside. The process of evaporation needs energy which is drawn as heat from the water thereby producing its temperature. The tribal communities in Koraput, Mayurbhanj and Kandhamal as well as the coastal villages in Kendrapada, Jagatsingpur and Puri have refined these cooling techniques over the centuries. These designs are climate responsive architecture which was developing without using the modern (HVAC) system. The contemporary “Eco housing” projects are also using this process for ecologically sustainable living. The aforementioned examples can be used to teach the young adults as to how the indigenous architecture of Odia household utilises the principles of thermal conductivity, convection, specific heat capacity, evaporation and latent heat and radiative heat transfer unknowingly. These solutions provide an energy efficient cooling system in the era of global warming and climate change.

Ethnoscience in Agriculture of Odisha

Traditional ploughing (Langala) where wooden ploughs that are pulled by oxen to cut the soil. The depth of the plough and its angle was decided by soil type. Metal tips were put on the wooden ploughs which lessened the friction with hard or rocky soil. The plough acted as a lever to turn the soil and break it. Oxen gave kinetic supply which was transferred to the plough. Irrigation practices in tribal regions used bamboo pipes or sloped canals which were known as *Jalasrota* in tribal areas [41] [46] [21]. In Ganjam, Kandhamal and Koraput paddy fields were arranged in terraces. The irrigation used three concepts of physics. The first one is of fluid dynamics wherein flow is dependent on elevation, pressure, and pipe diameter. The second principle is of gravitational potential energy where water moves from higher elevation to lower elevation [13] [32]. The third principle is of conservation of mass where peasants ensured the flow of water is balanced across the fields [47] [5] [18]. The concept of mechanical advantage was used to reduce the force needed. Farmers used to transplant seedlings of paddy keeping in mind the soil moisture and moon phases. As per thermodynamics the retention in soil moisture is connected to evaporation rates and absorption [39] [23] [17]. As per hydrodynamics the puddle farming regulates the seepage and oxygen availability for the plant roots. The storage bins and granary were made of cow dung, mud, and bamboo. Mud and clay

have less thermal conductivity which keep the temperature relatively stable thereby leading to insulation of foodgrains which would keep its freshness for long period [36]. Moreover, the concepts of ventilation and airflow also come into the picture as natural convection currents allow dryness and deter fungal growth. Peasants would time the sowing with lunar cycles and forecast precipitation using bird calls, wind, and cloud patterns. The sunlight and moonlight have a considerable impact on the circadian rhythm and evaporation in flora. The gravitational tides caused due to moon's gravitational pull affects soil moisture thereby affecting the plant growth cycles.

Table 1: Principles of Physics and Traditional Practices of Odisha

<i>Traditional Practice</i>	<i>Associated Physics Principles</i>	<i>Explanation</i>
Konark Sun Temple	Astronomy, Acoustics, Magnetism, Optics, Structural mechanics, material science	Sundial wheels, Sun alignment, Musical pillars, Magnetic idol of Sun God, Design of the temple complex as a chariot, Stone selection for durability
Puri Jagannath Temple	Astronomy, Acoustics, Magnetism, Optics, Thermodynamics, Aerodynamics	Visibility of Neela chakra from any location, Silence in inner sanctum, No Birds or Planes fly directly above the temple, Temple height seems to be the same from any location in puri, Shadow falls on itself, Top pot cooks First, Flag fly opposite to wind
The Puri Ratha Yatra	Energy absorption, Friction, Structural mechanics, Motion, Force	Modern brake system for shock absorption, Challenges of putting a brake system in the chariots, Structural integrity of wood, Pulling the cart
Ancient Water Harvesting System	Gravity, Fluid Dynamics, Percolation, hydrostatic, Capillary action,	Gravity flow system, Embankment for water retention, Ground water recharge, seepage control, Silt settling
Pottery	Friction, Heat transfer, Material transformation, Rotational mechanics, Centripetal/Centrifugal Force	Control of friction with water, Temperature effects on clay property during firing, Atmospheric control in kilns, Potter's manipulation of clay on spinning wheels

<i>Traditional Practice</i>	<i>Associated Physics Principles</i>	<i>Explanation</i>
Weaving	Material Properties, Tension, Force, Motion	Maintaining uniform tension for fabric density, Loom mechanism for shedding, picking and beat-up, interlacing wrap and weft threads
Maritime heritage of Odisha	Torque, Equilibrium, Vector force, Bouncy, Aerodynamics and Newton's Third law	Balancing the boat, Placement of cargo in sheeps, Adjusting the sails, To design the hull for better distribution of the Boat's weight, Forward movement of boat
Traditional cooling methods of Odisha	Convection and radiation, thermal insulation and heat transfer, evaporative cooling,	Air circulation in open central spaces, mud walls and thatch roofing, water evaporate in clay pots
Traditional agricultural practices of Odisha	Insulation and heat regulation, gravitational flow , mechanical advantage and force,	Granary and storage store foodgrains, terraced farming , ploughing

Integrating Ethno Science in Undergraduate History Education

Inclusion of Odisha's Ethnoscience heritage into undergraduate history curriculum gives a solution to present educational obstacles. This method blends local wisdom with scientific concepts, giving learning experiences that are both contextual and relevant. This teaching model is effective in introducing problems that demand critical thinking, urging students to judge information rigorously, compare a verity of solutions and reach logical decisions. The goal is to inculcate critical thinking and process scales in learners, allowing them to link scientific concepts to their daily lives [48]. This will lead to a shift from a fact memorization approach towards and experiential model, where learning happens through inquiry. By Looking at our historical Tangible heritage through the lens of ethno science students discover the scientific principles incorporated in it. KIIT University offers an M.Sc. in Physics with a specialisation in indigenous knowledge in Science and Technology. This provides a real-life academic precedent for interdisciplinary integration at master's level. The instance gives a model to be followed for undergraduate history departments. NEP 2020 has advocated for multidisciplinary approaches in tertiary level of education to provide academic freedom to students. (Abonyi et al 2014, Shukla et al 2022, Sharma 2024) History departments in Odisha must leverage the

liberal policy of NEP 2020 to design a curriculum that promotes interdisciplinary engagement aligning with constructivism, experiential learning and connectivism. Ethno science will be instrumental in fostering cultural appreciation among the young adults, who will be motivated to preserve their cultural identity. Students will learn to identify the scientific concepts in their customs and feel a sense of pride in it. The real-world problems will be seen in an integrated knowledge perspective where solution will not be limited to any one academic silos [48] [49]. Innovative technologies are bringing new ways of teaching interdisciplinary concepts. Use of technologies like Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR) can give immersive learning experiences. VR transform history teaching into an interactive experience, where students can literally visit the historical places. For example, Students can be asked to virtually visit the Konark sun Temple and observe its Architectural features or they can witness the Puri Ratha Yatra in the classroom and immerse themselves in the devotional fervour and see the concepts of physics coming alive in front of their eyes. The ability to be present in the historical environment mixes the indigenous knowledge alive. Thereby, reducing the gap between theoretical knowledge and real-life application. Lecturers can use google arts and culture, Merge Cube+, Merge EDU, BlippAR, Oculus, ZapWorks, ThingLink, AR Makr, iOS Only, Unity with Vuforia (AR) to teach Ethnoscientific concepts at Undergraduate level in Odisha.

Strengths

This paper tries to bring forth a fresh perspective by connecting history andragogy with ethno-science, an area which has not been previously explored in Odisha. It documents the local scientific practices making history and science relatable to students. It bridges the contemporary physics and historical ingenuity, demonstrating how antiquated practices can strengthen modern understanding. This is an interdisciplinary study that draws from history, physics and education. It can make classroom teaching more engaging and fosters pride in indigenous knowledge systems. This paper builds a foundation for future studies on education and ethnoscience at tertiary level of education.

Limitations

This research paper focuses on Odisha which limits its generalizability to other regions of India. Cultural practices can differ widely across various communities.

Analysing and interpreting the ethno-scientific practices in terms of physics may lead to simplification. Students and teachers are used to traditional history teaching may not easily accept the idea of inclusion of ethno-science considering it less historic and difficult to intergrate with the undergraduate curriculum. Some traditional practices do not have the experimental verification under the controlled scientific methods.

The Need for Further Research

Further research can compare and contrast ethno-science practices of Odisha with those in other Indian provinces or nations to point out the common features and unique characteristics which can enrich the global understanding of the indigenous physics knowledge. Studies should centre on designing and evaluating structures teaching models that integrate ethno-science into history curriculum without compromising the core concepts. Interdisciplinary research is needed to make an all-encompassing framework linking history with science and society. Long term studies are required to assess the impact of ethno-science based andragogy on learners' employability skills, scientific thinking and cultural appreciation.

Conclusion

“To understand the present, you have to know the past. And to know the past, you must understand the science that made it possible.”

—Carl Sagan

This paper has shown that Odisha's local knowledge, Historical practices and cultural heritage are profound repository of applied physics. From the marvellous engineering of the Konark Sun Temple to the complex mechanics of handlooms and the sustainable water management systems of our ancestors, Physics is incorporated in every solution which had made the life of people easier. Ethnoscience illuminates as to how our cultural practices have assimilated scientific understanding and problem-solving strategies evolved over Millenia. History is to be seen as a narrative of human genius and technological progress used for the good of the community. Courses at under graduate level should be redesigned to explore ancient technologies through the lens of Physics. For example, a module on ancient Indian engineering could dive into the magnetic principles of Kalingan

Architecture. A module on local crafts can also be included to traverse the material science behind weaving and pottery. An inquiry driven, hands on pedagogy should be implemented to teach history in an interdisciplinary manner. Students can be asked to go to craft villages, Field trip to historical sites and engage with local artisans to learn the reverse engineering conventional technology and find out the scientific basis underlying it. Emergent technology like Augmented Reality and Virtual Reality can be used to create interactive simulation of traditional processes that can transmute obscure concepts into tangible experiences, fostering student comprehension. Teachers need to be given comprehensive training to integrate interdisciplinary instruction using technology. The classroom process should be inclusive and must be able to resonates with the needs of underserved areas. Student exchange programme should be encouraged which will make interdisciplinary learning a reality. There should be collaboration between the departments of history, physics, engineering, and archaeology to further analyse document simplify and disseminate Odisha's Ethnoscience heritage (Arundev 2024, Kumar 2025, NEP 2020). Odisha's Undergraduate education should be directed towards a holistic model that honours the unique scientific legacy embedded in their socio-cultural history.

Author's Contributions

1. SWAGATIKA MEHER: Conceptualization of the study, drafting, reviewing
2. ISHITA MISHRA: Conceptualization of the study, drafting, reviewing
3. DR. DIPANSHU SHARMA: Editing and Reviewing

All Authors reviewed and edited the manuscript and approved the final version of the manuscript.

Acknowledgements

The authors would like to extend the gratitude to the P.G. Department of History at Ravenshaw University and P.G. Department of Physics in Utkal University for helping the authors with gathering the sources for the paper. The authors are also indebted to Harekrushna Mahatab State Library in Bhubaneswar for providing access to valuable books.

Disclosure Statement: No potential competing interest was reported by the authors.

Funding: This research was not funded.

References

- [1] Ministry of Education, Department of School Education and Literacy , “Shikshak Parv,” in NCERT, New Delhi, 2021.
- [2] Ministry of Education, Government of India, “National Education Policy 2020,” 29 July 2020. [Online]. Available: https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf. [Accessed 6 August 2025].
- [3] Ministry of Education, Government of India, “National Curriculum Framework for School Education- 2023,” 6 April 2023. [Online]. Available: chrome-extension://efaidnbmninnibpcajpcgiclfindmkaj/https://dsel.education.gov.in/sites/default/files/guidelines/ncf_2023.pdf. [Accessed 6 August 2025].
- [4] M. Aitken, “ Physics applied to archaeology—part II,” *Contemporary Physics*, vol. 3, no. 5, pp. 334-352, 1962.
- [5] S. M.-W. A. H. M. RAPHAEL UCHÔA, “Science and Its Others: Histories of Ethnoscience.,” *History of Anthropology Review*, pp. 1-16, 2024.
- [6] T. A. S. ., M. E. N. ., H. W. ., A. R. Arief Aulia Rahman, “ Meta-Analysis: The Effect of Ethnoscience-Based Project Based Learning Model on Students' Critical Thinking Skills.,” *Jurnal Penelitian Pendidikan IPA*, vol. 9, no. 9, pp. 611-620, 2023.
- [7] E. S. Grobsmith, “Ethnoscience as a Methodology In Indian Education: A Sioux and Apache Example.,” *Transactions of the Nebraska Academy of Sciences and Affiliated Societies* , pp. 14-23, 1973.
- [8] C. Hime, “ Ethnoscience: An educational concept.,” *Minorities in Science*, pp. 259-266, 1977.
- [9] H. C. Behera, “ Traditional agriculture, culture and the indigenous knowledge (IK) among the Kondhs in Odisha,” *Journal of Huma Ecology*, vol. 73, no. 1-3, pp. 44-55, 2021.
- [10] S. Harding, “Is modern science an ethno-science? Rethinking epistemological assumptions.,” *Science and Technology in a Developing World* , vol. 19, pp. 37-64, 1997.
- [11] G. Kumar, “ NEP 2020 and The Vision of Holistic Education: A Conceptual Study of Integrative Knowledge.,” in *Multidisciplinary Education: Emerging Paradigms in the Context of NEP 2020*, Mumbai, Redshine Publishers, 2025, pp. 90-97.
- [12] K. P. Koirala, *Connecting Vedic and ethno science with school science curriculum of Nepal (Doctoral dissertation, Faculty of Education, Science)*., Kathmandu: Tribhuvan University, 2023.
- [13] D. P. Madavkar, “ Indian knowledge system (IKS),” *Mandavkar, P. (2023). Indian knowledge system (IKS)*. , 2023.

- [14] V. D. Jr, "Ethnoscience and Indian Realities.," *ERIC*, vol. 7, no. 3, pp. 12-18, 1992.
- [15] F. N. M. W. D. N. M. M. C. M. Para Mitta Purbosari, "Culturally Responsive Teaching Approach Training Based On Ethnoscience.," *International Journal of Community Care of Humanity (IJCCH)*, 2(4), 363-368., vol. 2, no. 4, pp. 363-368, 2024.
- [16] Y. S. M. O. & V. B. M. Biba Jasmine, "Traditional knowledge systems in India for biodiversity conservation.," *Indian Journal of Traditional Knowledge*, vol. 15, no. 2, pp. 304-312, 2016.
- [17] A. S. W. R. Yohanes Freadyanus Kasi, "A thematic review on exploring ethnoscience in science education: a case in Indonesia.," *Jurnal Keguruan Dan Ilmu Tarbiyah*, , vol. 6, no. 2, pp. 229-241, 2021.
- [18] S. B. Brodt, "A systems perspective on the conservation and erosion of indigenous agricultural knowledge in central India.," *Human Ecology*, vol. 29, no. 1, pp. 99-120, 2001.
- [19] D. P. K. a. D. A. Niyogi, "The Indian knowledge system and indigenous pedagogies: A historical and contemporary review," *IUJ Journal of Management*, vol. 13, no. 1, pp. 9-27, 2025.
- [20] S. B. Brown, "A Festival of Chariots: How Music and the Arts Take the Hindu Temple Experience to the Streets. Religions, 15(12), 1456.," *Religions*, vol. 15, no. 12, p. 1456, 2024.
- [21] H. S. Putra, "Ethnoscience a bridge to back to nature.," *E3S Web of Conferences* , vol. 249, p. 01002, April 2021.
- [22] M. Mishra, "Traditional knowledge systems, culture and environmental sustainability: concepts from Odisha, India.," *Communication, Culture and Ecology: Rethinking Sustainable Development in Asia* , Springer Singapore., pp. 51-66, 2017.
- [23] E. I. a. A. A. Nwosu, "Effects of Ethnoscience and traditional laboratory practical on science process skills acquisition of secondary school biology students in Nigeria.," *British Journal of Multidisciplinary and Advanced Studies*, vol. 1, no. 1, pp. 35-46, 2017.
- [24] K. K. M. a. N. H. Deepak Kumar, "Exploring the Urban Fabric of Religious Spaces: Determinants of Puri's Urban Form.," pp. 167-179, 2024.
- [25] S. K. Puri, "Integrating scientific with indigenous knowledge: Constructing knowledge alliances for land management in India.," *MIS quarterly*, vol. 31, no. 2, pp. 355-379, June 2007.
- [26] W. K. M. P. K. & S. G. Subhamoy Jana, "23. Jana, S., Mohanty, W. K., Kumar, P., & Gupta, S. (2021). Neotectonic activity along the Odisha coast, India: Implications for the collapse of the Konark Sun temple and extinction of the ancient River Chandrabhaga.," *Journal of Earth System Science*, vol. 130, 2021.
- [27] B. Patra, "Maritime Heritage of Early Odisha as Reflected in Archaeology, Texts and Traditions.," *Language, Literature, Culture & Integrity*, vol. 2, pp. 38-54, 2020.

- [28] S. P. a. D. S. K. Bhuyan, “ Jagannath Culture and the Dynamics of Folklore: A Social Cohesion and Universalism in Odisha,” *India : A Cultural Mosaic*, pp. 76-83, May 2025.
- [29] K. Ganesh, “ Forging a ‘Maritime Identity’for India,” in *Maritime India: Temporal and Spatial Continuum*, New Delhi, National Maritime Foundation , 2024, pp. 3-25.
- [30] K. K. Hota, “Architectural Engineering of Konark Sun Temple: A Sustainable Model from Ancient India.,” In *Indian Knowledge System Through The Ages: From Vedas to Modern Science*, Mumbai, Redshine Publishers, 2025, pp. 194-203.
- [31] A. S. Junghare, “ The Architectural Study of Sun Temples in India: Based on Location, Construction Material and Spatial Analysis Study.,” *International journal of scientific and research publications*, vol. 11, no. 1, pp. 331-338, 2021.
- [32] N. Sadhale, “49. Sadhale, N., & Bagh, H. (2006). Water harvesting and conservation in ancient agricultural texts. *Asian Agri-History*, 10(2), 105-120.,” *Asian Agri-History*, vol. 10, no. 2, pp. 105-120, 2006.
- [33] K. a. V.Onkar, “ The Pottery of Physics: Why we must question the polarisation of learning into academic and non-academic, curricular and extracurricular,” *Economic and Political Weekly*, vol. 52, no. 48, pp. 94-95., 2017.
- [34] K. M. a. D. Chatterjee, “ The cultural dimension of environment: Ethnoscience study on Santhal community in eastern India.,” *International Journal of Anthropology and Ethnology*, vol. 5, no. 1, p. 16, 2021.
- [35] D. S. Sharma, “Scientific Approach to Indian Knowledge System and NEP 2020.,” *International Journal of Advanced Research and Multidisciplinary Trends (IJARMT)*, vol. 1, no. 2, pp. 173-179, 2024.
- [36] S. S. M. a. A. D. Mohapatra, “ Sustainability of handloom: a review.,” *Ilkog. Online Elem. Educ. Online*, 19, 1923-1940., vol. 19, no. 3, pp. 1923-1940, 2020.
- [37] C. Jaffrelot, “The Hindu nationalist reinterpretation of pilgrimage in India: the limits of Yatra politics.,” *Nations and Nationalism*, vol. 15, no. 1, pp. 1-19, 2009.
- [38] D. R. B. ., D. S. Susanta Bahinipati, “ The Konark Temple’s Construction: A Critical Review of the Historical, Cultural, and Scientific Evidence.,” *National Library of Medicine F1000Research*, vol. 13, p. 1540, 2025.
- [39] E. T. U. S. & Z. J. Sharon Nelson-Barber, “ Indigenous rural students’ attitudes and perceptions about ethnosience in STEM instruction.,” 38. *Nelson-Barber, S., Trumbull, E., Sexton, U., & Johnson, Z. (2023). Indigenous rural s Indigenous STEM Education: Perspectives from the Pacific Islands, the Americas and Asia*, vol. 29, pp. 239-262, 2023.
- [40] P. A. K. Pradhan, “ Maritime heritage of Orissa. Orissa Review,” *Orissa Review*, vol. 54, pp. 51-56, 2005.
- [41] D. S. K. Patnaik, “ Maritime Heritage of Odisha: Beacon and Background.,” *Odisha Review*, vol. 74, no. 4, pp. 73-77, 2018.

- [42] D. A. P.R., "India's New Education Policy NEP 2020: Vision for Multidisciplinary Learning And Research.," In *Paradigm Shift: Multidisciplinary Research For A Changing World*, vol. 2, Delhi, Redshine Publishers, 2024, pp. 30-35.
- [43] D. B. a. S. Sahoo, "Odra: Naval and Merchant Vessels (Maritime science heritage: Sanatan Nau vigyan: Select discussions)," *Maritime Technology and Research.*, vol. 4, no. 2, pp. 1-17, 2022.
- [44] B. P. B. a. K. Vijayaragavan, "Evaluation of indigenous knowledge systems of traditional rice farmers in India.," *Journal of sustainable Agriculture*, vol. 18, no. 4, pp. 39-51, 2001.
- [45] H. C. H. & R. B. M. Madhu, "31. Madhu, M., Hombegowda, H. C., & Bishnoi, R. (2025). Blending Traditional Knowledge of Farmers in Agriculture with Modern Scientific Technologies in Hill and Tribal Areas of Odisha. In Blending Indian Farmers' Traditional Knowledge in Agriculture with," *Springer*, pp. 631-649, 2025.
- [46] S. Sahai, "Indigenous knowledge and its protection in India," in *Trading in Knowledge*, London, Routledge, 2003, pp. 166-174.
- [47] A. D. Gupta, " Way to study indigenous knowledge and indigenous knowledge system.," *Research Journal of Recent Sciences* , vol. 4, pp. 16-29, 2012.
- [48] L. A. & N. M. I. A. Okechukwu S. Abonyi, " Innovations in Science and Technology Education: A case for ethnosience based science classrooms.," *International Journal of Scientific and Engineering Research*, 5(1), 52-56., vol. 5, no. 1, pp. 52-56, 2014.
- [49] R. A. Fasasi, "14. Fasasi, R. A. (2017). Effects of ethnosience instruction, school location, and parental educational status on learners' attitude towards science. *International Journal of Science Education*, 39(5), 548-564.," *International Journal of Science Education*, vol. 39, no. 5, pp. 548-564, 2017.
- [50] P. C. A. Priya Priyadarshini, " Promoting tribal communities and indigenous knowledge as potential solutions for the sustainable development of India.," *Environmental Development*, vol. 32, December 2019.