International Technology Research Journal (INTERJ)

# Integration of Mechatronics and Autotronics in Technical Education for Greater Technological Innovation in Nigeria

**Anthony O. Ezeama[1], Victor I. Oguejiofor[2] & Benjamin B. Uzoejinwa[3]**

**[1,3]Department of Agricultural & Bioresources Engineering,**
**[2]Department of Mechanical Engineering,**
**[1,2,3]University of Nigeria, Nsukka**
[1]osita.ezeama@unn.edu.ng
[2]victor.oguejiofor@unn.edu.ng
[3]bejamin.uzoejinwa@unn.edu.ng

## Abstract

*This paper has offered a viewpoint on the integration of mechatronics and autotronics in technical education for greater technological innovation in Nigeria. Mechatronics is an advanced engineering design approach in which there is a coordinated, concurrently developed, integration of mechanical engineering with electronics, intelligent computer control in the design and manufacture of products, and processes. Autotronics is simply automobile mechatronics. The automotive industry seems to be the most common, advanced innovative area of mechatronics application and need highly qualified workforce who are to be trained through technical education for revenue generation and job creation. As, science, technology, and engineering education are applied/advanced forms of technical education that brought about improvements in the automotive industry. Processes dictate that jobs and skills change, so too must the educational offerings change as teachers and students are expected to bring about the change. Hence vehicles of the future like the unmanned aerial vehicle (UAV) will require ever more sophisticated technology, changing the skills demanded of auto designers, engineers and production workers in Nigeria, so the integration of modern technology is imperative and innovative. The curriculum of technical education should be reviewed to include all aspects of the modern automotive systems in order to offer enough skills needed to meet the challenges of maintenance in the sector. The review should be tripartite in nature to provide the theoretical information on mechatronics and autotronics at the level of technical education, provide recent precision demonstrators and simulators as device for learning of automobile technology, and practical applications of the mechatronics and autotronics tools in vehicle systems diagnosis.*
***Keywords:*** *Mechatronics, autotronics, integration, technical education, innovation*

## Introduction

Today's world robots are all around us, they come in a variety of shapes and sizes, designed to do an extraordinary range of tasks. Typically, when we think of robots, we picture these big humanoid robots from films like "Transformers" or the big robotic arms seen in manufactured cars on automated assembly.

The advent of microcomputer, embedded systems such as electronic chips, sensors etc, and associated information technologies and software advances have resulted in speedy evolution in engineering design and application of the concept of mechatronics. Furthermore, advancements in semiconductor and integrated circuits manufacturing led to the development of a new class of products that incorporate mechanical concepts and electronics in their systems and require the two together for their functionality. Mechatronics is therefore an advanced engineering design approach in which there is a coordinated, and concurrently developed, integration of mechanical engineering with electronics and intelligent computer control in the design and manufacture of products and processes. In such products and processes, many mechanical functions are replaced with electronic ones. This results in more enhanced flexibility, easy redesign and reprogramming, and the ability to carry out automated data collection and reporting. Figure 1 is an illustration of how mechanical process and information processing have together developed towards mechatronic systems.

According to [Harshama et.al, 1996], mechatronics is a blend of mechanics and the synergistic use of precision engineering, control theory, computer science, sensor and actuator technology that were designed to improve products and processes. Mechatronics can also be described as the totality of fundamentals and techniques in a unified framework for service and production of future orientated machines and products. Before the 1990s there was pure mechanical systems such as steam engines, dynamos, circular pumps, combustion engines and mechanical typewriters. Around the 1920s to 1930s there was mechanical systems with electrical drives resulting to relays, solenoids, hydraulic, pneumatic, electric amplifiers and PI-controllers, and in 1930 there was electric typewriter [Bishop, 2006]. In 1935, there was mechanical systems with automatic control, transistor in 1948 and thyristor in 1955, mechanical systems with electronic(analog) and sequential controls of 1955resulting to digital computer of 1955,process computer of 1959,real time software of 1966, microcomputer of 1971, and digital decentralized automation of 1975 having electronic controlled lifts. Next, there was mechanical system with digital continuous and sequential controls of 1975 which gave rise to microcontroller of 1978, personal computer of 1980, process/fieldbus systems, new actuators and sensors, and integration of components having machine tools, industrial robots, industrial plants and drive disk involving increasing automation with process computers and miniaturization [Bishop, 2006]. Then the new age of mechatronic systems of 1985 with integration of

mechanics and electronic hardware and software which determines functions, new design tools for simultaneous engineering, and synergetic effects were developed from 1985. These gave rise to mobile robots, CIM, magnetic bearings, automotive control (ABS,ESP), etc. Mechatronics continues to increase in integration of process and microcomputers [Bishop, 2006].

Unlike the conventional engineering design approach, mechatronics design involves design, data extraction, output generation, processing, automation, display, performance evaluation and future integration. An industry is a plant organized to produce products and goods needed by people or industry. Accuracy with which the parts/goods are produced depends on machine capability [Harshama et.al, 1996]. Improvement in the quality of product requires improvement in machine capabilities which is greatly enhanced by mechatronics. The need for mechatronics in industry can therefore be summarized as follows [Harshama et.al, 1996]: changing market condition, variety in product ranges, short production runs, good product quality and consistency, enhancement in process capabilities, demand for increased flexibility. In the industry scenario, the following are some challenges faced by manufacturers in the Mechatronics area [ASME, 2005]: lack of integrated data management, software configuration management, difficulty in reducing cost, supplier management, compliance management. Compliance to Restriction of Hazardous Substances (RoHS) and Waste Electrical and Electronic Equipment (WEEE) regulations require tracking of the material specifications right from the design stage. The related processes are still maturing in this area [ASME, 2005].

**Table 1: Properties of conventional and mechatronic design systems**

| S/N | Conventional design | Mechatronic design |
|---|---|---|
| | Added Components | Integrated Components |
| 1 | Bulky | Compact |
| 2 | Complex mechanisms | Simple mechanisms |
| 3 | Cable problems | Bus or wireless communications |
| 4 | Connected components | Autonomous units |
| | Symbol Control | Integration by Information Processing (software) |
| 5 | Stiff construction | Elastic construction with damping by electronic feedback |
| 6 | Feed forward control, linear (analog) control | Programmable feedback (non linear) digital control |

| | | |
|---|---|---|
| 7 | Precision through narrow tolerances | Precision through measurement and feedback control |
| 8 | Non measurable quantities change arbitrarily | Control of non-measurable estimated quantities |
| 9 | Simple monitoring | Supervision with fault diagnosis |
| 10 | Fixed abilities | Learning abilities |

Probably the most advanced area of mechatronics application is in the automotive industry. Autotronics is automobile mechatronics. Autotronics can be divided into two aspects: one is the automotive electronic control devices which were integrated with the mechanical system in the vehicle applications. Automotive electronic control is a combination of mechanical and electrical devices, they include engine power, sensor system control (images, acceleration, pressure or temperature, etc.), electro-mechanical control (X-by-wire, electronic fuel injection systems, ABS, skid control, electronic control suspension, electronically controlled automatic transmission,etc.); the other aspect is the on board autotronic devices which are electronic devices that can be operated independently in a car environment, they are not directly related to the automobile's performance, safety, or control, they include integrated on board machines, satellite navigation systems, audio-visual entertainment systems, etc. As a result, the automobiles have been integrated with electronic control technologies such as sensors, micro-controller unit (MCU), the image and display (camera & display), on board unit (OBU), satellite positioning, wireless communications, semiconductors, power devices, and even portable devices are used to connect vehicles with the customer service center via wireless links.

Autotronics is entering a rapid growth stage, and has opened investment opportunities for manufacturers. The reasons why product quantity and values have been increasing yearly are (i) automotive sensors and the semiconductor technology are mature, and their costs have been reduced (ii) car manufacturers use the autotronics products to increase competitive advantages, and to meet the demands of product differentiation (iii) to improve engine efficiency and to lower fuel consumption through mechanical or electronic control (iv) consumers improved their awareness of vehicle safety (active, passive safety) (v) the increased demand for wireless information and communication for cars. Automotive industries in Nigeria as a matter of fact should key in well with the global modern automotive technological advancement. The global auto industry is undergoing three simultaneous technological transformations: the propulsion revolution, the connectivity revolution and the autonomy revolution. The connectivity revolution is putting Internet services, from satellite navigation systems to advanced telecommunications, into vehicle dashboards. The autonomy revolution is moving to stage of driverless car and is

already creeping in as a form of radar that can sense a potential collision and automatically apply the brakes. Autonomous vehicles detect surroundings using radar, lidar, GPS, Odometry, and computer vision show contribution of autotronics in the modern automotive industry. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage. Autonomous vehicles have control systems that are capable of analyzing sensory data to distinguish between different cars on the road, which is very useful in planning a path to the desired destination. An alternative classification system based on six different levels (ranging from driver assistance to fully automated systems) has been published by Society of Automotive Engineers (SAE), an automotive standardisation body. This classification system is based on the amount of driver intervention and attentiveness required, rather than the vehicle capabilities, although these are very closely related. The new breed of autonomous weapons as artificial intelligence weapon (AIW) is not a welcomed idea in the world today because they are slightly easy to reprogram, allowing anybody to create an efficient and indiscriminate killing machine at an incredibly low cost. Such advance technology should not be advocated for in Nigeria technical education sector because it will result to integration of an innovation that has negative effect in education system.

**Technical education and technical colleges**

Technical education is entirely practice-oriented both in principles and practice as could be deduced from the description of such programmes. Technical education encompasses science, technological, and engineering education. Technical and vocational education is the foundation of any nation's wealth, development and innovation. This kind of education do produce semi-skilled, skilled and technical manpower necessary to restore, revitalize, energize, operate and sustain the national economy and substantially reduce unemployment in Nigeria (Federal Government of Nigeria, 2013). It is a form of education involving, in addition to general education, the study of technologies and related sciences and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life (FGN, 2013). This specialized education is offered in technical institutions saddled with training of lower and middle level manpower, including technical colleges. Technical Colleges in Nigeria are established to produce craftsmen at the craft (secondary) level and master craftsmen at the advance craft (post-secondary) level (Federal Ministry of Education, 2013).

**Integration of mechatronics and autotronics in technical education**

The main objective of ICT in teaching and learning jargon is to facilitate a faster and better understanding and enjoyment of the subject matter in such a way as to obtain the maximum possible result from the teaching and learning process as it concerns integration of mechatronics in technical education. We have to review what is involved in the training of technical education teachers and students that will help structure the analysis of the most appropriate

policies, institutions and capabilities necessary to increase innovation in the broad sense of it [http://www.lastveb.com/page/apprenticeship.aspx].The key institutions involved in the creation of knowledge are curriculum planners, public R&D laboratories, universities, and private R&D centres. All creation of knowledge is the result of formal R&D effort. Technologies often must undergo adaptation to be applicable in specific local conditions. The skill needs of the nation is still to meet with the recent precision stage. The stages should be (1) provision of theoretical technical information on mechatronics and autotronics that march the level of technical college education; (2) provision of recent precision demonstrators and simulators as a teaching aid for learning automotive technology; (3) practical application of the mechatronics and autotroics tools in diagnosis of vehicle systems faults. Definitely we have low skilled man power as the medium skill man power needs to undergo training. This need is particularly clear in agriculture and automobile, where new technologies such as hybrid seeds and vehicles are very sensitive to specific local conditions which the medium skill man power should be made to handle. To meet local needs, further research, training and experimentation is often required to adapt in order proffer solutions to specific conditions. The skills necessary to adapt technologies to local conditions are not too dissimilar from those necessary to create new technology [http://www.lastveb.com/page/apprenticeship.aspx]. Dissemination of knowledge requires appropriate mechanisms to educate potential users in the benefits of the related technology, often a process inclusive of broad educational advance, not just the provision of technical information that match with the level of skill man power capacity building need. This involved explicit training, demonstration projects, or technical assistance on how to use the new technology. To use new technologies usually requires literacy as well as specialized training. Thus the integration of mechatronics in technical education is a global innovation that should be embraced.

**Current innovations in technical education for Modern Automobile Maintenance in Nigeria**

Technical education centre's exists in private and public sectors in the Nigeria. Some of the centres have adequate facilities for modern automobile maintenance. All the technical colleges, polytechnics and universities offering motor vehicle mechanics trade, mechanical engineering technology (auto option) and automobile engineering respectively have the capacity to key into the modern automobile maintenance. Other available modern automobile maintenance training centres is the private sector that is owned by individuals who set up the business solely for profit making and less training interest.

To ensure that vehicles produced are of good quality, and NAC is currently building automotive component test centres and laboratories to conduct vehicle homologation and other comprehensive tests of parts and components that would enhance overall product quality. Training policy is necessary to sustain global pace for technological development because of

interchangeability (identical parts and can be used globally). Thus, training and information has to be made available for trainees to meet with global world of work. Technology should be provided by Nigeria Vocational and technical colleges and training centers, for trainees receive additional skills during the training.

As such the Lagos State Technical and Vocational Education Board (LASTVEB) is committed to the strategic development of provisions which would address the critical skills shortages currently seen as a barrier to the successful growth of key industries and business in the state. LASTVEB has an established network of five (5) technical colleges and to enhance the quality and capacity of this provision to international standards. School Leaver Modern Apprenticeship Programme (SL-MATP) and Graduate Vocational Employability Skill Training Programme (GV-ESTP) are there two initiatives that is managed by the Apprenticeship Training Programme department of LASTVEB. Apprentice learn on the job, building up knowledge and skills and gaining qualifications at the same time from any of the Government Technical Colleges (GTCs), Skills Acquisition Centres (SACs), Vocational/Youth Centres (VYCs) and accredited training providers. These valuable skills will help them secure employment in the future. There are various levels of apprenticeship available: Young apprentices: level 1 (aged 14-16 years old\0 for \JSS III (BEC graduate), an intermediate apprenticeship: level 2 usually last for about a year to 18 months, and an advanced apprenticeship: level 3 last for at least two years. While "Employability" is designed for graduates who want to learn the skills necessary to gain work. Graduates selected will learn generic skills required by all employers, such as: Personal/Interpersonal skills, thinking/Information Processing skills, Systems/Technology skills, and Start your business (SYB). The GV-ESTP programme allows trainee graduates to explore different vocational subjects. These trainings will expose trainees to best practices and recent technologies in accordance with current technological trends and industries open window for individual's academic progression. NAC has started discussions with some state governments and the various industrial clusters to facilitate training. The three existing auto-clusters in Nigeria, namely Lagos-Ogun-Oyo, Kaduna-Kano and Enugu- Anambra, will also serve as established zones around which NAC will strategically facilitate more investments by international OEMs, and their strategic global suppliers that will also accompany them into Nigeria. The Industrial Training Fund (ITF) is already working with SENAI in Brazil to design auto training centres similar to what they have in Brazil in the three existing Nigerian auto clusters (Lagos-Ogun-Oyo, Kaduna-Kano and Enugu-Anambra). These centers will not only train Nigerians to maintain andservice vehicles, but will also train them to manufacture spare parts. NAC, with the Nigerian Universities Commission and other stakeholders, has been working on University degree programmes by developing a curriculum for a degree in automotive engineering. Two Universities, Abubakar Tafawa Balewa University (in Bauchi) and Elizade University (in Ondo) already have plans to offer the programme.

Also, NAC, with the National Board for Technical Education (NBTE), Federal Ministry of Labour and Productivity and other stakeholders, have developed a new curricular for teaching automotive mechanics. This forms part of the new National Vocational Qualifications (NVQ) scheme approved by the government recently.

## Conclusion

This paper has presented a perspective on mechatronics, and autotronics, with particular emphasis on the need to integrate into the technical colleges in Nigeria for useful advancement in modern technology. The automotive industry seems to be the most common and advanced area of mechatronics application which Nigeria can easily and readily tap into as a means of revenue generation and job creation at the same time. All stake holders including the government, educational and research institutions, the industry, entrepreneurs, etc. should play their necessary roles in developing this promising sector which can become an important driver of Nigeria's economy in the near future if properly harnessed as being done in countries like China. In the general cum technical education, it is consequently regrettable that despite government efforts to encourage teachers to adopt the use of ICT in the teaching and learning process, many teachers are still lagging behind in acquiring the requisite modern technology skill in their professions. It is on this backdrop that this paper wishes to emphasize the need to integrate into technical education system the study of mechatronics and autotronics in Nigeria. There is no doubt that science, technology engineering, and technical education compliment each other to result to the global modern technological advancement. The new breed of autonomous weapons as artificial intelligence weapon (AIW) is not a welcomed idea in the world today because they are slightly easy to reprogram, allowing anybody to create an efficient and indiscriminate killing machine at an incredibly low cost. Such advance technology should not be advocated for in Nigeria technical education sector because it will result to integration of an innovation that has negative effect in education system.

## Recommendations

The following recommendations were offered hopeful that the required strategies to help to eradicate some of the barriers to the use of ICT in technical education and integrate mechatronics and autotronics learning and application for human sustainability:

• The use of ICT for teaching and learning in technical education should be encouraged stackholders. Computer instruction and application of modern technology should therefore be made compulsory for teachers and students at all levels of our educational systems but most especially in the technical education. To achieve this, curriculum planners must enforce the inclusion of the use of ICT and computer education and training in school curricula.

• Educators should continue to place more emphasis technical education and implement

educational technology as a means of enhancing the quality of education.

• In-service training workshops for professional development on educational technologies should be organized for teachers, particularly on the production and use of computerized instructional materials. Technical education student-teachers must receive in-service training that will render them relevant to today's knowledge age.

• Schools should be equipped with computer and Internet facilities and other necessary instructional tools like slide, video presentations simulator, demonstrator and auto scan tools.

It is necessary that teacher trainers must also be trained so that they are able to impart ICT training to student teachers in the technical education system.

**References**


Adebanjo, D (2014). Intermediation in Down Stream Automotive Supply Chains-A Review of the Role of Internet Technology. *International Journal of Automotive Technology and Management* 8[1] 12-55

ASME (2005). Global trends and best practices in Mechatronics. Retrieved from *http//www.ASME on 08/08/16.*

Balot, E., Segrestin, B. and Weil, B. (2008). Another look on Product Diversity: Some New Propositions to Design Pro_table Product Ranges, *International Journal of Automotive Technology and Management*. 8[1] 12-55

Bishop, R.H. (2002). *The Mechcanotric handbook*. New York: Texas CRC Press.

Bishop, R.H. (2006). *Introduction to mechtronic*. U.S.A: Taylor & Francis Group, LLC.

Ekere N. (2007). *Automotive Electronics - Opportunities and challenges for Nigeria's Auto Sector. Retrieved from: http://www.nac.org.ng on 08/08/16*

ElMaraghy, W. (2009). Knowledge Management in Collaborative Engineering. *International Journal of Collaborative Engineering.* 1[12]114-124

FGN (2013). *National policy on education.* Abuja: NERDC.

Harshama, F., Tomizuka, M., and Fukuda, T. (1996). "Mechatronics—What is it, why, and how? IEEE/ASME 1

Kyura, (1996). N. and Oho, H. "Mechatronics—an industrial perspective," IEEE/ASME Transactions on Mechatronics, 1[1]

Mori, T., "Mechatronics (1996). *Yasakawa Internal Trademark Application* 21[131]

Suh, N. P. (2009). Designing and Engineering through Collaboration and Negotiation; *International Journal of Collaborative Engineering*. 1[12] 19-37

Tukur, B. (1994). *The Future of the Nigerian Automotive Industry*. Enugu ANAMMCO 2[12].