GMSA Chair as an Example of University-Industry Collaboration

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***Abstract*—The aim of this paper is to demonstrate the importance of close industry-university collaboration which benefits students and industry. In 2009 the Chair of Mechatronics was established at Nelson Mandela Metropolitan University (NMMU) in collaboration with General Motors South Africa (GMSA). Over a period of seven years, this initiative has grown into a strategic partnership, which plays an important role in engineering education and the community at large. The methodology of cooperation was chosen such that it would address educational as well as industry related problems. The results of this initiative can be seen in a significant number of industry based projects completed at the GMSA plant by NMMU engineering students, demonstrating the benefits of this collaboration for both partners. One of the major advantages for the NMMU students is that they are exposed to the most modern manufacturing technologies, which can strengthen their knowledge and benefit them in their future careers. For industry, this collaboration is also beneficial as it makes a significant impact on human capital development in the automotive field through skills development and research. In conclusion, for the country at large, this collaboration addresses one of the biggest challenges of the South African economy, which is the skills shortage in the manufacturing sector.**

***Index Terms*—industry collaboration, educational chair, training**

I. Introduction

Modern engineering education is greatly supported by applied research based on university-industry interaction. Over the years, the Nelson Mandela Metropolitan University (NMMU) has establsihed partnerships with South African automotive companies, such as GMSA, Volkswagen and Ford. The focus of NMMU-GMSA collaboration is on strengthening university-industry partnership in order to enhace the educational process and facilitate the knowledge trasfer from academia to industry. The establishment of the GMSA Chair of Mechatronics coinsided with the introduction of the Bachelor Degree in Mechatronics, which was the first full engineering degree in the Eastern Cape.

Human capital development has been recognised as one of the most important challenges for the fast growing South African economy. The SA government introduced a number of initiatives to tackle the problem of skills shortage in the country, including the skills development levy act [1], which is used for training of unskilled labour. It has been widely recognised that education, skill levels and problem-solving abilities of a workforce are important for the country to be competitive globally [2]. For South Africa, which is a young, developing nation, the importance of comprehensive human capital development is high, especially in the manufacturing sector as it contributes the most to job creation. Despite the difficult global and local economic climate, South African companies recongise the need to invest in resources that develop human capital in the most efficient and results-orientated manner [3].

The long-term collaboration of NMMU with the automotive companies in the form of engineering chairs demonstrates that they can significantly contribute to effective human capital development by means of increasing the knowledge base and skills of future engineers and technicians, as well as workers. According to Soon [4], in order for university-industry interaction to be mutually beneficial they need to fulfill three key roles, namely: the identification of niches in high technology industries, the improvement of productivity in manufacturing industries, and the provision of research and development services for industry. Therefore, it is important that members of academia and members of industry work jointly when focusing on these interactions.

According to Henaff [5], university-industry collaboration requires a continuing cycle of three main activities:

- The attainment of scientific or technological knowledge
- The creation or production of knowledge
- The transfer of the acquired technology

All three activities can be achieved by means of solving industry problems through undergraduate students' projects, as well as by conducting applied research on the postgraduate level to address more fundamental engineering problems, which may arise in real industry.

This paper describes the further developments of the GMSA Chair of Mechatronics and its importance in the context of engineering education [6]. The paper presents case studies, which demonstrate the impact of the Chair activities on the educational process, skills development and engineering activities at GMSA.

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II. Role of the GMSA Chair

The GMSA Chair of Mechatronics was established in the School of Engineering in 2009 and since then it has been fully supported by GMSA. From the beginning, the primary aim of the Chair was identified as follows: to foster a long-term, mutually beneficial collaboration between academia and industry in meeting their strategic objectives. The aim was to be achieved in the accomplishment of the following tasks: research, training and education, knowledge transfer, and assistance in development and problem-solving activities in industry. It was envisaged that these activities would result in an improved level of company competitiveness through greater skills development and the application of leading technologies in the workplace, and would benefit the educational process. It is important to highlight that the company engineers were actively involved in the process to ensure that a solid partnership is developed to maximize the potential benefits for all parties involved. The partnership made a significant contribution to engineering education in the newly established Bachelor Degree program in Mechatronics at NMMU by providing industry support and additional resources for the program. As a result, the program was successfully accredited by the Engineering Council of South Africa in 2011.

In order to achieve the objectives, the Chair applied the following methodology and activities Fig. 1. Firstly, the Chair together with GMSA engineers established a list of projects that are important to the company. These projects are classified according to the priorities and the level of complexity. Typically, projects fall under various fields of engineering; therefore, university students not only from mechatronics, but also from mechanical, industrial and electrical engineering departments undertake industry-based projects at GMSA or related automotive component suppliers. Students are supervised by academic and industrial mentors while seeking engineering solutions to particular industry problems based on relevant theory and technical knowledge, and then develop full concepts for implementation in the industrial environment.

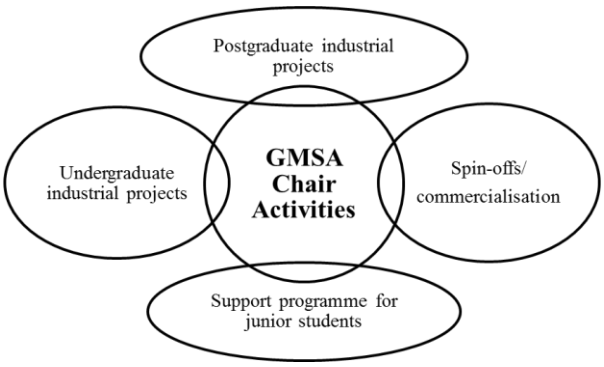

Figure 1. GMSA Chair activities chart

Since the majority of projects are undertaken by undergraduate students, in the process, besides gaining new knowledge, students gain valuable practical experience thanks to the exposure to professional expertise in real industry. On the other hand, this mode of cooperation provides industry with solutions that are often unique, innovative and at the lowest cost. In the process, a fast transfer of knowledge is facilitated by open and regular communication between students, academics and engineers.

In the Chair, postgraduate students are involved in high level research projects, which fall under the company's long-term objectives. This is the second direction pursued by the Chair. Research topics are linked to critical production processes, where solutions may require substantial time and significant resources, but may result in higher productivity and efficiency. Hence, research projects are also relevant to the automotive sector, particularly within the context of the South African manufacturing environment. These research activities are primarily directed towards low-cost automation, human-machine interaction, robotics and material handling.

Often, these projects involve international collaboration with partner universities in Europe and USA providing world-class research and facilitating student exchange programs. In addition to bringing industry solutions, this activity results in scientific publications and conference presentations. The research activities of the Chair include knowledge transfer by hosting scientific seminars and guest lectures with international speakers, and the presentation of specialized training courses that are important to industry for skills development.

The third direction of the Chair is the commercialization of research outputs by means of establishing sound businesses as spin-offs of the engineering and research activities, which will contribute to innovation, and as a result, to job creation in the country.

The fourth area of the Chair activities involves support for first-year students, especially those from the previously disadvantaged communities, to bridge the knowledge gap between school and university engineering courses. Through the years, this gap has been identified as a major factor contributing to the high failure rate at the beginning of the course. The Chair introduced a mentorship program, where senior students help junior students to acquire the necessary learning skills to master engineering courses. As a result, the throughput of the Mechatronics degree program has significantly improved.

III. GMSA Chair Projects

As mentioned above, the key strategic objectives of the Chair are to provide support for engineering education and to assist industry with problem solving and development in the field of manufacturing. This university-industry interaction provides numerous benefits to both partners, which will be presented in the examples of case studies undertaken by the Chair.

A. Benefits for Industry

The industry-related benefits can be broken down into three categories namely: (a) engineering solutions and designs for low-cost automation, (b) solutions for

complex engineering and production issues, and (c) skills development. Many students' projects undertaken by the Chair can be used to showcase industry-related benefits in terms of low-cost automation. Some of the major benefits gained by industry through the activities of the Chair are skills development and continuing education of professionals in industry. In order to address long-term complex issues, the Chair conducts research in collaboration with a number of international partner universities in Europe and the USA, primarily focusing on the fields of robotics and automation. A number of postgraduate students from NMMU have conducted research visits to Germany, or the USA focusing on projects which are important for industry. All of these activities contributed positively to human capital development and increased competitiveness of the automotive industry.

There are many advantages for industry and students in solving of real industrial problems or working on new designs for industry. It has been noticed that students are strongly committed to working on projects which they believe might have a real impact in industry. In this case, benefits extend beyond the obvious benefit of a working solution to an industry problem, to the inclusion of knowledge transfer, the application of different technologies, innovation of solutions, and human capital development. Working solutions are usually implemented in industry, which gives students a sense of pride and fulfillment. Three such projects are briefly showcased below.

1) Case study 1: Development of a station control system for an engine assembly line

Figure 2. Photograph of the assembly line and the control diagram

The engine assembly line shown in Fig. 2 is a continuous type conveyor with no designated stations. The base engine block is loaded at the start of the line, from a hoist, onto a fixture. All assembly operations are performed whilst the engine remains on the same fixture and moves down the line. A worker assembles a specific set of components on the engine and then pushes the engine manually along the line to the next worker. The problem is that the fixture is pushed uncontrollably down the line and often collides with another fixture, which could result in damage to the engines. A worker's hand could also get trapped between fixtures, creating a safety concern. Hence, an undergraduate student was required to design a pacing and station control system for the engine assembly line.

The student successfully completed the project and developed a prototype of the system, which allows control of the assembly line in such as a way that no collision of engines is possible. This low-cost effective solution was well received by GMSA and implemented in real production.

2) Case study 2: Development of a low-cost AGV

The manual car assembly line required additional automation in the area of material handling to improve efficiency. Within this framework, it was decided to design a low-cost Automated Guided Vehicle (AGV) applicable to the South African automotive industry, as well as to similar low volume GM plants worldwide. This project was accomplished in stages by three Master's degree students, who designed a number of prototypes of low-cost AGV. During the design and implementation processes, the students worked closely with the GMSA production engineers and maintenance team in order to improve ergonomincs of the final design and to satisfy the stringent safety requirements. The latest AGV design was recently implemented in real production at GMSA where it has been undergoing extensive trials, as shown in Fig. 3.

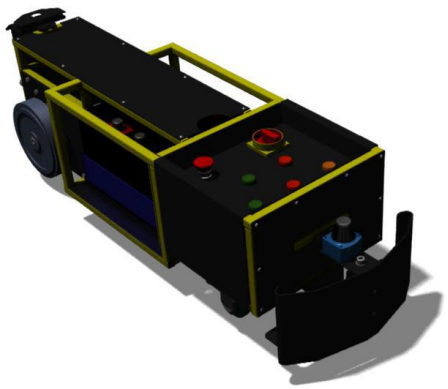

Figure 3. Low-cost AGV model

The development of a market-ready design of an AGV is an outstanding example of an innovative solution, which can lead to commercialisation of research outcomes. The AGV design is currently in the process of registration. It is envisaged that a spin-off company will be establsihed as a result of this research project, which will produce AGVs for local manufacturers and

warehouses. A team of industrial engineering students developed a business plan for this initiative as part of their undegraduate studies [7]. The SWOT analysis results are shown in Table I indicating good potential for a sound business case.

TABLE I. SWOT ANALYSIS

Strengths: • Able to provide a low cost and flexible AGV to the local market. • The developed AGV is a low cost solution compared to existing high-tech solutions in the AGV market. • Modular design of the AGV makes it flexible.	**Weaknesses:** • The developed AGV is only able to contend on a cost level, rather than on a technological level, with competitors offering more advanced AGV systems.
Opportunities: • Limited manufacturers of AGVs in South Africa. • Manufacture and distribute AGVs locally, to be the preferred local supplier of AGVs. • Manufacture and distribute affordable AGVs to the small-to-medium sized firms, which have not been well provided for due to the high costs of AGV offerings from competitors. • The industry demand for manufacturing is anticipated to grow at an average annual rate of 2.4%, resulting in an increase in demand for AGVs used in manufacturing. • The demand from transportation and warehousing is also expected to increase at an average annual rate of 2.9% until 2018, with the probability of causing an increase in AGVs used for the transportation of raw materials and inventory. • The economy is improving and more companies are interested in using automation to increase productivity and lower operating costs. • Escalating labour costs make the AGV a viable solution.	**Threats:** • Competition from international competitors who offer more technologically advanced systems, offering higher modularity (flexibility) and intelligent material handling. • Technologically more advanced AGVs offered by competitors, are able to use open-path navigation, rather than external navigation networks such as wire, mirrors or magnetic strips, which the developed AGV is unable to offer at present. • Economic downturns resulting in fewer AGVs purchased. • Unions opposing the use of AGVs at companies due to possible labour reductions caused by the use of AGVs.

This example also shows the direct benefit for the univeristy, as the spin-off company will generate an additional income for the university, new jobs for engineering graduates and funds for student bursaries.

3) Case Study 3: Development of an automated charging station for AGVs

The project focused on the development of an intelligent charging station for the low-cost AGVs, complete with autonomous docking of the AGVs at the station (i.e. an integrated docking and battery charging station for the AGVs). The primary aim of the station was to allow for semi-automated battery swapping for the AGVs. To this end, voltage monitoring on the AGV detects when battery levels are low and directs the AGV to drive itself to the charging station. The operator is simply required to connect / disconnect the power plugs from the AGV and charger, and to initiate the sequence from a Human Machine Interface (HMI) screen.

The student successfully completed the project and demonstrated the design in the form of a fully functional model, as shown in Fig. 4. The semi-automated solution incorporated a shuttle pod system and a horizontally actuated retrieval and gripping mechanism for transfer of the battery packs.

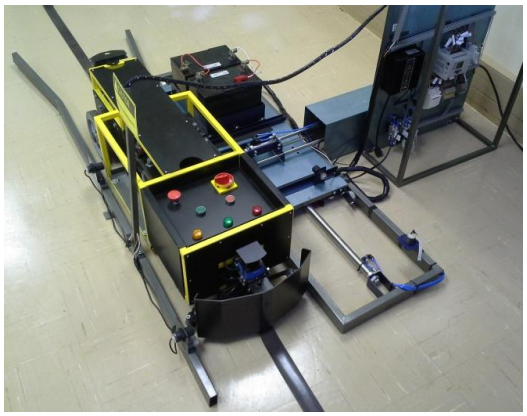

Figure 4. Photograph of the automated docking and charging station for AGVs

The project was examined by a GMSA senior engineer who commended the student for developing a sound engineering solution, which is low-cost, ergonomic and satisfies all production requirements. The developed station design has been proposed for use with the prototype AGVs at GMSA plant as a complete engineering solution.

B. Benefits for the Universty

The active participation of students in real industrial projects provided by the Chair brings many benefits for the university as well. These benefits include: additional funding, access to real production facilities and equipment, expertise of engineers, etc. Students have the opportunity of working on interesting and challenging projects that are closely tied to the local industry. Training courses, workshops and conferences arranged by the Chair benefit staff and students directly.

Automotive companies continuously introduce the latest technologies and, therefore, academics and students can have greater opportunities for obtaining new knowledge and improving their skills. The Chair together with GMSA engineers creates many opportunities for staff and students to conduct applied research in industry, which can facilitate high level skills development in certain areas and specializations.

The sponsorship of students participating in various international competitions is another important aspect of this collaboration. For example, since 2009 the Chair regularly sponsors students participating in the

WorldSkills competition (London, Vancouver and Leipzig thus far). Additional funding generated by the Chair is used for supporting junior students through a mentorship program, which proved to be an efficient intervention for improving throughput in the Department of Mechatronics.

In addition to these human capital development activities, the university-industry collaboration contributes significantly to engineering education in general. For example, engineering students have access to real manufacturing technologies and processes in the early years of their studies. Furthermore, students are exposed to situations that they will experience in the working environment in the future, and learn from these. Regular interaction with practicing engineers and their assessment of students' projects is another important aspect of the learning process. All these activities aid students in their studies and better prepare them for their future careers in industry. As can be seen from above, this is achieved mainly through the participation of students in industry-based engineering projects, working individually or in groups, in various engineering subjects. Two case studies that demonstrate these benefits are presented below.

1) Case study 4: Design of a manipulator for rear bumper installation

In this project it was required to design a manipulator to aid the operator in fitting the rear bumpers on the new generation Isuzu pickups. The rear bumpers are delivered to the assembly line on special pallets, and require two operators to remove a rear bumper from the pallet and install it. This was a complex design task as the bumper must be accurately positioned on the chassis. Additional constraints placed on the design were limitations on the overall cost and the provision of compressed air or electrical power to the mobile unit. The designs that were presented by the 3rd year students in groups offered a variety of different implementations of a common strategy of solving the problem, which was based on a mobile manipulator with a vertically and horizontally actuated gripping device Fig. 5. Two final designs of the manipulator offered viable solutions to the problem according to the assessment performed by the GMSA engineers.

Figure 5. Design of a special manipulator for bumper installation

2) Case Study 5: Design of an automated cleaning station

The project required the design of an automated cleaning station to handle cleaning of the hangers in the pre-treatment and e-coat lines in the paint shop Fig. 6, as the currently method of cleaning is labor intensive and inefficient.

The project was tackled by 3rd year mechanical design students in groups as part of an undergraduate course. The designs offered a variety of different strategies of solving the problem, each closely aligned to the specifications of the current station layout, cleaning procedure and available equipment. The most promising project was selected by the GMSA engineers for further consideration. This design potentially could be used as the basis for implementation of a hanger cleaning system in the paint shop. Furthermore, the students also learned many aspects of engineering design, which are important in real practice, through this project.

Figure 6. Photograph of the conveyer with C-hangers

IV. Conclusion

This paper presents the development of a joint university-industry initiative. Following its establishment in 2009, the Chair has now been active for seven years and has achieved sound results through a number of projects and initiatives. The Chair can be viewed as an example of successful university-industry collaboration, which makes a significant impact on human capital development and engineering education. Through the industry-based projects and research, it has been shown that such collaboration can provide mutual benefits for all partners involved.

The main goal of such university-industry collaboration is the development of human capital – both in terms of young graduates, who receive the necessary skills while studying at an institution of higher education, and in terms of continuous professional development for engineers already in industry by enhancing their knowledge through research and development. The case studies shown above demonstrate that there are many benefits, which include: the funding of and participation in high level research activities, the solution of industry-based engineering problems that combine theoretical expertise of academic institutions with practical expertise

from industry, and the fostering of improved education, skills development and specialisation.

University-industry collaboration in the form of a structured engineering Chair can provide an excellent platform for improving engineering education and human capital development, which have been identified as important factors requiring consideration in all spheres of the modern economy. Engineering Chairs, such as the GMSA Chair, are important providers of such development and have a significant impact on the community as the whole. While greatly benefitting universities and students, such cooperation also improves competitiveness of the local industries and contributes to job creation and sustainable growth.

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REFERENCES

[1] Skills Development Act. (1999). Department of Labour. Republic of South Africa. [Online]. Available: http://www.labour.gov.za/DOL/downloads/legislation/acts/skills-development-act/Act%20-%20Skills%20Development%20Levies.pdf

[2] T. Hershberg, "Human capital development: America's greatest challenge," *Annals of the American Academy of Political and Social Science*, vol. 544, 1, pp. 43-51, March 1996.

[3] M. Marimuthu, L. Arokiasamy, and M. Ismail, "Human capital development and its impact on firm performance: Evidence from developmental ecomonics," *The Journal of International Social Research*, vol. 2, no. 8, pp. 265-272, 2009.

[4] C. T. Soon, "University-industry collaboration: Current practices and future directions in education and technological development," *Journal of Materials Processing Technology*, vol. 23, pp. 1-6, 1990.

[5] J. Henaff, "Engineer's education: University-industry interactions," in *Proc. the MELECON '89 Electrotechnical Conference*, Lisbon, 1989, pp. 721-725.

[6] I. A. Gorlach and A. R. Norman, "Industry sponsored engineering chairs as a platform for human capital development," in *Proc. ISEM Conference*, Stellenbosch, 2011, pp. 166.1-166.9.

[7] H. Meyer and M. Dolley-Ryneveld, "Business plan for a local AGV solution," *Research Report*, Dept. Ind. Eng., NMMU, Port Elizabeth, South Africa, 2014.

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