A framework for optimizing the functions of engineers working in the SA Didactic Market

Serge E M Tankam, Barend W Botha
Faculty of Engineering and Built Environment,
University of Johannesburg, South Africa
sergeemmanuel2002@gmail.com
bwbotha@uj.ac.za

Abstract. Didactic Solutions Engineers are those engineers who are involved in providing sales, marketing, training, and customer solutions of learning systems in an organization. These complexities attached to the nature of Didactic Solutions Engineering functions within an organization often create a sense of exhaustion, thus reducing productivity and efficiency. Applying knowledge of systems engineering methods and tools with systems thinking have been used effectively to optimize complex problems. This paper discusses using these methodologies in developing a framework for optimizing the function of a Solutions Engineer in the didactic market with specific application to Festo South Africa (SA).

Keywords: Didactic Solutions Engineers, Systems Thinking, Systems Engineering, Optimization, Enterprise Resource Planning (ERP)

Introduction

Festo defines the engineers involved in providing sales and other multifunctional roles associated with learning systems and the transfer of knowledge from one generation to the other as Didactic Solutions Engineers. The current structure of the company, where the role of the Didactic Solutions Engineer is continuously evolving often sees the solutions engineer involved in some unrelated tasks such as submitting proposals, preparing tender documents, working on marketing and exhibition content as well as being a technical product trainer and acting as the support technician. This leads to exhaustion of human resources which in turn reduces efficiency and effectiveness. Developing a framework to optimize the function of these engineers within the structure of the company can reduce risk and frustration to both the engineers as well as the company.

Systems engineering originated in the defense industry from the development of large, complex, operational systems with generally well-defined objectives. Anderson & Nolte indicate that the shear duration and budgets of these projects make the stakes high offering good potential for systems engineering. This is generally not the case in commercially driven research and development programs. Such projects typically emphasize creative discovery governed only by general goals and relatively limited budgets (Anderson & Nolte, 2005).

Application of systems engineering processes and procedures developed for the large, requirements oriented programs to smaller, exploratory programs usually produces poor results, if any. For an exploratory program to benefit from the knowledge embodied in systems engineering processes an understanding of the basic principles is necessary (Krueger, Kevin, David , R. Douglas, & Cecilia, 2010) to customize the process to suit the intended purpose. As an example, the principles of identification of customer needs, problem solving, design and optimization will be used for this study.

With this in mind, this study aimed to use systems engineering skills and tools together with systems thinking to propose a framework to optimize the daily functions of the Festo Didactic Solutions Engineer in context to the South African market. This study starts with a systematic literature review followed by defining the research methodology, the data collection methods, data analysis, data interpretation and proposed framework. Finally, the conclusion and recommendation are presented.

Literature Review

Vakhtina & Vostrukhin indicates that knowledge cannot be transferred to a student in the finished form. The educational system can only create pedagogical conditions for the successful mastering of concepts through the training environment (Vakhtina & Vostrukhin, 2014). Companies designing didactic equipment therefore need engineers to translate the customer expectations into the required need for didactic equipment. Engineers, analysts and managers are often faced with the challenge of making trade-offs between different factors to achieve desirable outcomes. Optimization is the process of performing these trade-offs in the most suitable way. The notion of different factors means that there are different possible solutions and the notion of achieving desirable outcomes means that there is an objective of seeking improvement on how to find the best solution (Onwubolu & Badu, 2004)

Sun et.al. (Sun, Kramer, Li, & Stuart, 2014) reviewed and summarized the product information from the major manufacturers and suppliers of didactic and learning systems equipment used in the training of renewable energy professionals (i.e artisans, technicians, technologists and engineers). They used the information technology forum Listserv where they posted the relevant questions. Multiple responses were received from eighteen institutions using those learning systems, and from four equipment suppliers. They compiled the manufacturer's list on their published work based on those responses and additional research. However, their investigation focused on renewable energy didactic and learning system manufacturers while further research revealed that most of the manufacturers, if not all, have a broad base of engineering disciplines, rendering the daily job of their Solution Engineers complicated.

Investigating learning system manufacturers and suppliers the functions of the Didactic Solutions Engineer was summarized to include the following:

- Push Didactic sales – training equipment for Technical Training Institutes, Engineering Colleges, Industrial Training Centres, and Vocational Training Centres etc.
- Business development activities to promote Didactic product range.
- Key Account Management.
- Create key accounts to offer training solutions.
- Carry out marketing activities to promote the Didactic business by organizing trade shows, exhibitions and others activities related to marketing.
- Solution sales to create project enquiries.

As shown above, sales is a major component and the main measurable output of the activities performed by a didactic solutions engineers. Developing the framework the emphasis is therefore weighted towards sales. In their work Arndt and Harkins identifies when it is appropriate to provide dedicated support for a sales activity (Arndt & Harkins, 2013), and in cases where support is desirable, how to explore the choice between core team support and external support. Their methodology focuses on sales transactions that typically require a diverse range of sales activities, including customer contact, scheduling appointments, internal meetings, processing orders, and preparing financing applications. The research develops a framework for understanding how to structure sales support for specific sales activities. According to their findings each sales activity has four dimensions, i.e.:

- workload
- customization
- complexity, and
- prequalification risk.

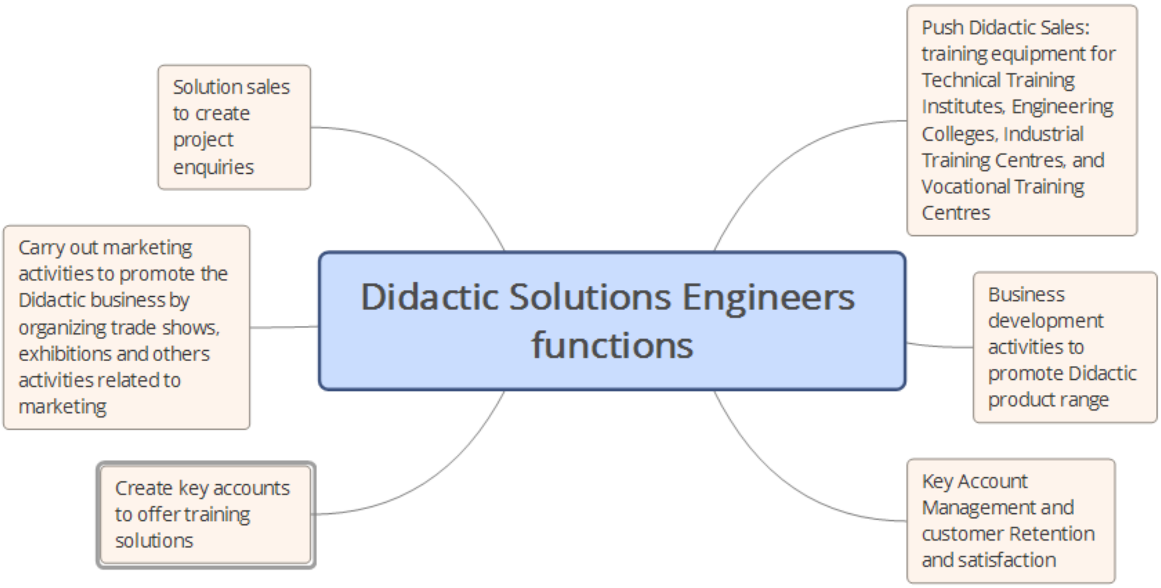

Figure 1**:** Functions of Solutions Engineers

Research by Locatelli et.al. (Locatelli, Mancini, & Romano, 2014) focused on systems engineering to improve the governance in complex project environment by addressing the project delivery, which is often late, over budget and with fewer benefits than expected when not using a system engineering approach. The result of the technique focused on the most relevant for project management, governance and stakeholder management. Their approach, however, does not emphasize how it is possible to leverage System Engineering (SE) for a more efficient system reuse. To successfully conduct their study, some recent publications were reviewed and analyzed for shortcomings and methodological approaches. Since the field is ill-defined, thorough research is needed to get appropriate publication for this research.

Dombrowska and Malorny (Dombrowski & Malorny, 2016) report on process identification for customer service as a basis for lean after sales services by observing the increasing competitive pressure in after sales services. A framework to optimize the customer services-processes was proposed to satisfy customer needs. The proposed approach seem to offer solid result, but it lacks a valid framework or holistic approach related to the general conditions and objectives of customer service. The results obtained show a methodical approach for OEMs that could create a structured process landscape. However, the lean principles to evaluate customer satisfaction was not applied.

Systems engineering offers a basis to act as integrator between engineering and business to achieve organizational goals with performance, schedule and cost as main topic of focus (Botha , 2016). This is being realized increasingly as companies are aligning different functions to work together to the benefit of the company (Dwight & El-Akruti, 2009).

Sanders and Klein (Sanders & Klein, 2012) designed a framework for using systems engineering tools for integrated product and industrial design including trade study optimization. They attempted to address the problem of affordability issues in aerospace and defense systems on the decision in supply chain and Systems Engineering. In their methodology, a framework is proposed to provide a structured hierarchical concurrent engineering approach to balance conflict performance and productivity requirements that impact systems affordability at each stage in systems design and development process. That resulted in a proposed novel approach for integrating manufacturing and supply chain considerations into the systems engineering process through the development of an industrial V-model which mirrors the conventional Product V-model.

Despite all the work done in literature, little or no work focuses specifically on didactic solutions and the position of the didactic solutions engineer within a company. The information can, however, be used in developing a framework to optimize the didactic solution engineering function.

Research Methodology

To obtain more detail information related to current practices, a qualitative approach was applied. A flexible standardized questionnaire interview format was subsequently developed and distributed to the respondents to allow for complex interactional variables that typically occur in a solutions engineering learning systems environment to be considered.

The logic and power of purposeful sampling lies in selecting information-rich cases to study in depth. Information rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the research (Patton , 1990). In this research, the methodology used include:

- Questionnaires derived from System Engineering Methodology,
- Personal interview of colleagues
- Analysis of data collected and
- Application of systems engineering principles to analyse results to derive a suitable framework.

QUESTIONNAIRE DERIVED FROM SYSTEMS ENGINEERING METHODOLOGY

The research instruments and tools used for gathering the data are pivotal to any research study and should be able to address the type of data in the research undertaken. Generally, there are various procedures of collecting data. The main instruments used in the mixed method researches consist of closed-ended, open-ended questionnaires, interviews and classroom observations. These different ways of gathering information can supplement each other and hence boost the validity and dependability of the data. With that in mind, the quantitative data are obtained through closed-ended questionnaires and the qualitative data through open-ended questionnaires, interviews and classroom observations (Zohrabi, 2013).

Systems Engineering (SE) is often said to be the framework for bringing a system into being. This can be achieved stepwise by combining the process, products and management tools already introduced. SE is therefore often introduced by Magerholm as a holistic methodological approach and constitutes a robust framework that can incorporate life cycle thinking, market share retention or penetration impact assessment and stakeholder views ((Magerholm FET , Systems Engineering Methods and Environmental Life Cycle Performance Within Ship Industry, 1997), (Magerhol, Aspen, Ellingsen, & Margrethe, 2013)). This methodological approach is introduced here by the six-step SE-methodology as shown in Fig. 2.

This methodology is a simplification of SE in general (Magerholm FET , Systems Engineering Methods and Environmental Life Cycle Performance Within Ship Industry, 1997) and builds upon the SE-models introduced by Blanchard and Fabrycky (Blanchard & Fabrycky, 1990) and Asbjornsen (Asbjornsen , 1999). However, before the engineering of a system takes place, it is important to have a good understanding of the objective of the client and the budget available.

Based on the above, Figure 2 was used as a framework for setting the questionnaire in this study.

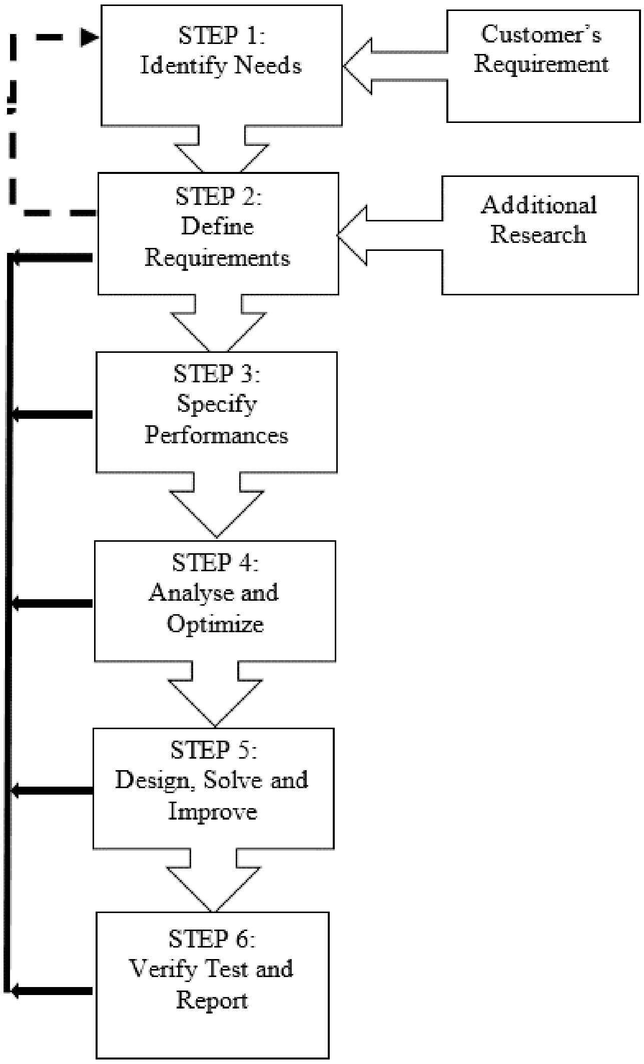

Figure 2: The Systems Engineering Methods (Magerholm FET , Systems Engineering Methods and Environmental Life Cycle Performance Within Ship Industry, 1997)

Step 1: *Identify needs*

First, the clients' or the potential client's needs should be collected. That will be done via different channels: during trade shows, telephonic conversation or customer visits. FET colleges, Training centers and University bodies may be primary stakeholders as they are main clients for learning systems, didactic equipment and solutions. Banks and cooperation organization such as GIZ, Don Bosco are also important factors that may have preferences pertaining to different standards and the performance levels.

Step 2: *Define requirements*

Based on the identified needs, the requirements for learning systems performance should be defined. Requirements may be expressed qualitatively e.g. by requiring the latest technology to be employed or to comply with relevant regulation, or quantitatively by number of learners or students to be trained and the system lifetime.

Step 3: *Specify performances*

After the requirements have been defined, the learning systems performance should be described for the system. A quantitative approach to measure performance levels should be chosen to the extent possible in order to facilitate precise analyses and comparison of alternatives. Quantitative information can be achieved from previous similar projects.

Step 4: *Analyze and Optimize*

In order to compare the performance of design alternatives in various scenarios, additional modeling and simulation techniques may be employed. The analysis- and optimization-phase most often demand trade-offs between alternative solutions, which can be done by e.g. Monte-Carlo-simulations. A challenge is often to derive weight factors that reflect real situations, and that are simple to use in a decision situation under time constraints. Identification of weights should be done by referring to the stakeholder involvement processes and surveys performed in steps 1, 2 and 3.

In the search for better alternatives, very often multi-variable problems occur, and the different parameters have thus to be weighted per their significance. In the optimization process, various alternatives may thereby be used as evaluation parameters. Once the criteria and weighing scheme have been established, the scores along various criteria for any alternative should be identified and taken into the design step. Very often there is uncertainty in the weights, and the objective functions that are used in the optimization process should therefore mirror the uncertainty.

Step 5: *Design and Solve*

In this step, alternative solutions should be introduced based upon the findings from the previous steps. The solutions might be new solution or an improvement of an existing solutions or even customization to client needs so that the initial needs and requirements are met with an optimized solution. It might also be managerial solutions for the implementation of strategic decisions to achieve sustainable solutions which might come out as the most beneficial seen from a market share retention and penetration.

Step 6: *Verify, test and report*

It is necessary to verify and test if the initial needs and requirements are met. Thus, considerations for tests and evaluation are innate from the beginning. Improvements of learning systems scenarios performance should be verified per initial requirements e.g. by means of the optimization parameters. There must be a database for future references.

The respondents

In this study, eight respondents were issued questionnaires. The respondents at the time of the study included solutions engineers, area managers and product managers from didactic companies around the world. These included four didactics solutions engineer at Festo South Africa and one at Festo Brazil, two were Area Manager Africa from DeLorenzo in Italy and Lucas Nuelle Germany respectively and the last one was a Global Product Manager from Festo Didactic Canada.

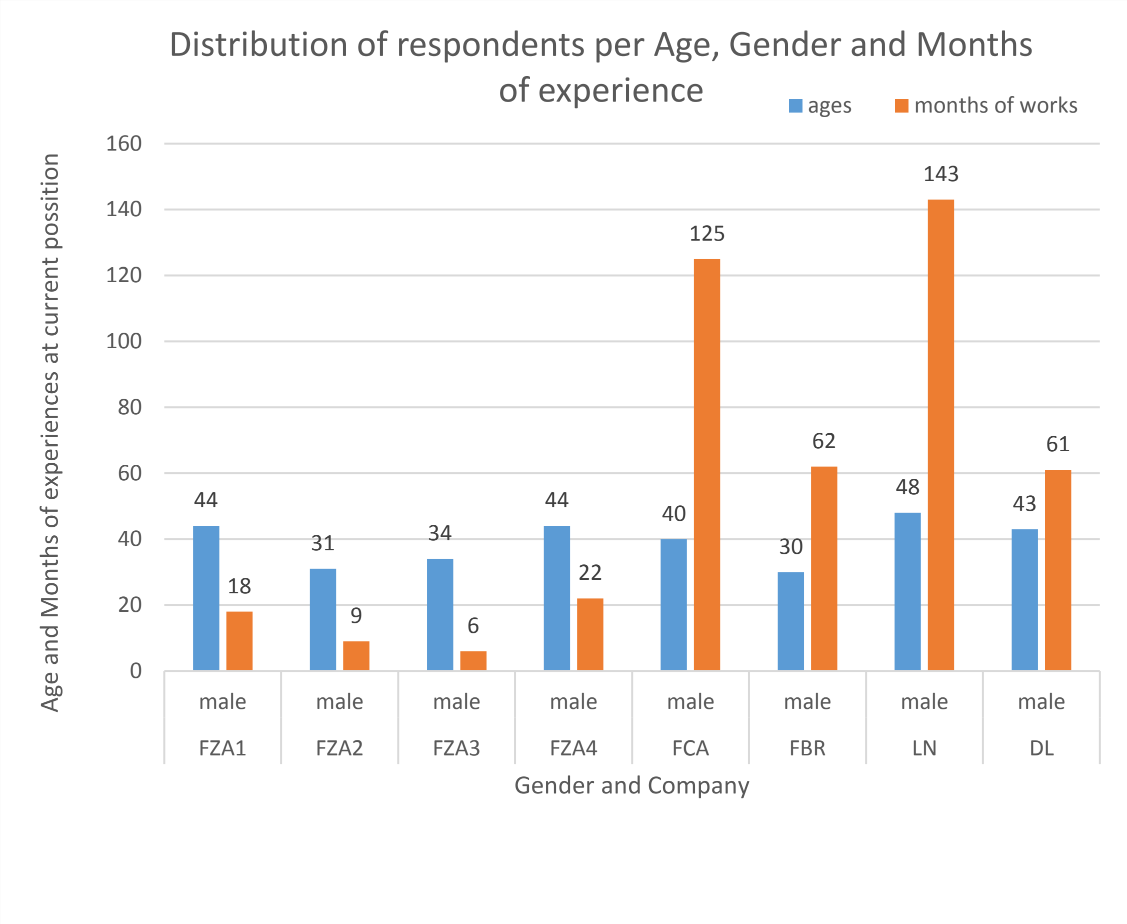

Figure 3: Distributions of respondents per Ages and Months of work in the current position.

Personal interview

Face to face informal non-structured interviews were also conducted during meetings and brainstorming process meetings with local colleagues in South Africa. In order to ensure open collaboration without fear of retribution no record of the interviews was retained.

Data Collection Methods and Tools

The questionnaire based on an open-ended question approach was used to gather information. Sung lists the characteristics of an open-ended questionnaire (Sung, 2005) as:

- Can elicit a wide variety of responses
- Good for exploring a topic
- Does not superimpose answers and expectations
- Can be difficult to summarize/analyze
- Response should be reported accurately

Based on the problem being addressed it is believed that the open-ended format with questions derived from Systems Engineering methods by Magerholm (Magerholm FET , Systems Engineering Methods and Environmental Life Cycle Performance Within Ship Industry, 1997) was the appropriate means to collect the data for this study.

Data Analysis and Finding

The qualitative data collected from the answers of the questionnaires was studied and analyzed. Based on the analysis of the answers provided, the systems engineering methods was then applied on the data collected (optimization, resources and cost analysis). The analysis generated the following information from the data collected:

- What did we learn?
- What conclusions can we draw?
- What are our recommendations?
- What are the limitations of our analysis?

After coding, analysis and interpretations of questionnaire answers, the framework below was generated and proposes as a daily tool that can be used to optimize the function of the didactic solutions engineer within Festo South Africa. A new organigram will also be proposed based on the vision and growth strategy.

Table 1: Finding coding and analysis

Procedures	**Aspects**	**Analysis**
Step 1 Identify Needs	• Sales interaction • Research • Customer visit • Trades show • Inbounds calls	Sales interaction and research and the primary sources to get customer needs followed by leads generated by trade shows and inbounds calls.
Step 2: Define requirements	• Personal • Define steps • Available tools	Usually requirements are done based on the Solutions Engineer abilities and knowledge on the products and using design tools available
Step 3: Specify performances	• Personal expertize • Advices from colleagues • Line manager inputs	The performance specifications are done based on the solutions engineers expertize and/or will collaboration with line managers and other colleagues
Step 4: Analyze and Optimize	• Previous solutions • Advice from line manager • Market strategies	The solutions engineers rely on either proven working solutions, advices from line manager or colleagues and market penetration strategies
Step 5: Design and Solve	• Previous solutions • Advices from line manager • International help • Quotation • Follow up	Use the tools available to quote and request help if needed
Step 6: Verify, test and report.	• Possibility to demo the solution • Availability of the equipment	Use available demo or simulations tools
Step 7: Other questions?	• Structure • Business process	Need to relook the current structure and the business process

Result and proposed framework

The data generated through distributing the questionnaire was analysed and interpreted. A Vee-model framework derived based on work by Forsberg and Mooz (Forsberg & Mooz, 1992) as shown in Figure 3 is proposed for the future functions of the didactic solutions engineer. The Vee-model is a 9-step model with six steps that can be implemented within the current structure (see Fig. 4) and three additional important steps if the proposed organigram (see Fig. 5) is adopted. The steps are listed below:

- Step 1: Understand Customer needs and get useful data
- Step 2: Define requirements and assess customer technical capabilities with the requested solutions
- Step 3: Specify performances and reassess that the proposed solutions match specifications.
- Step 4: Analyse and optimize the solution looking at price and completion offering
- Step 5: Design and solve by generating quote timeously, follow up and records interaction
- Step 6: Verify the proposed solutions, test with demo equipment if possible and report and record for future references
- Additional important steps if the proposed organigram is implemented:
    - Evolve to Project Management plan
    - Plan order fulfilment and installation
    - Test and customize if possible with the application Centre

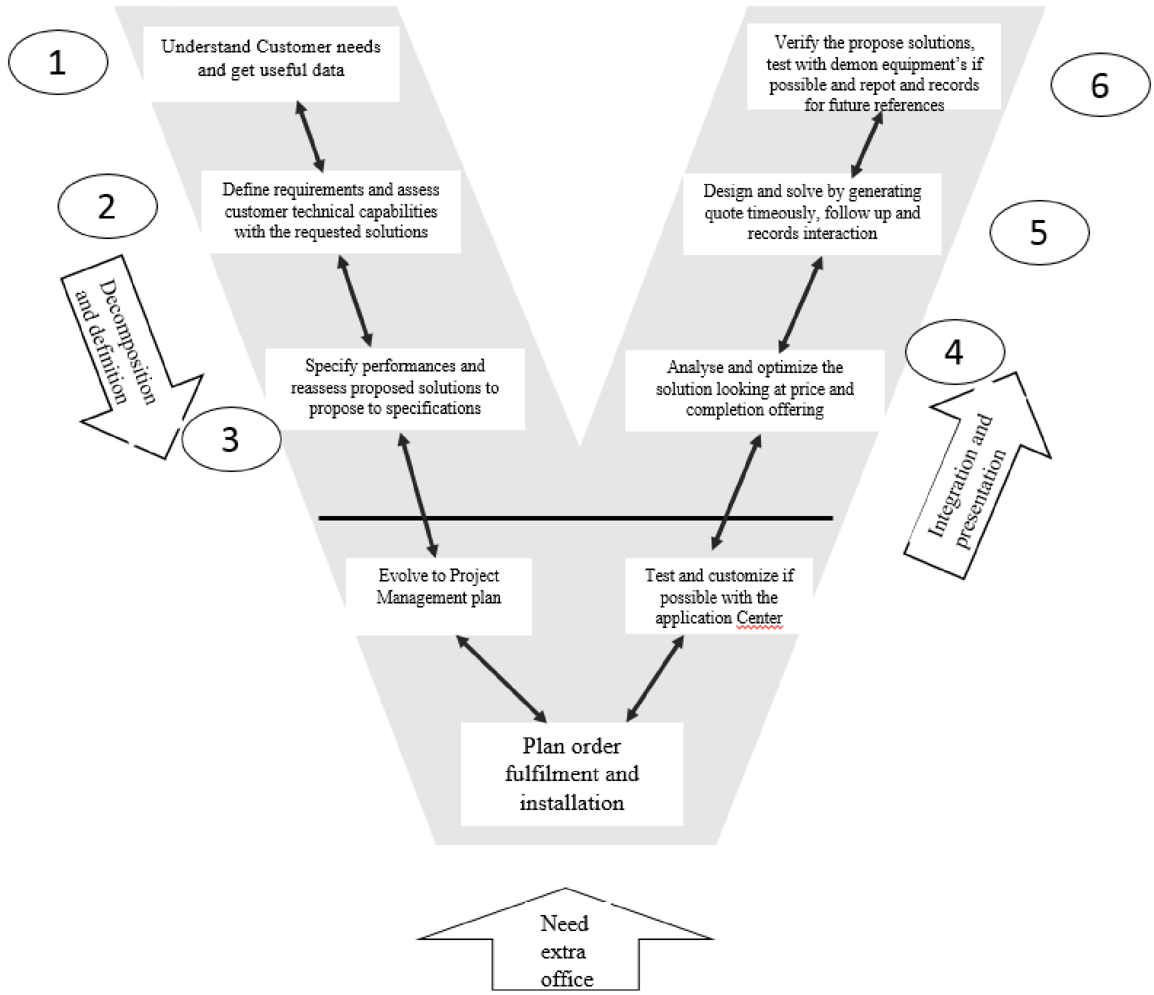

Figure 4: The Proposed Framework (adapted from (Forsberg & Mooz, 1992))

The current organigram in Figure 4, is based on geographical distribution and assume the solutions engineers should have the expertise in all the engineering fields Festo didactic offers. This offers the capacity to plan visits more efficiently and to constantly challenge the Solution Engineer to evolve and research in different technology areas. However, it is creating an environment where the engineer may not share his work and challenges within the allocated geographical area. Also, mistakes may only be discovered at an advanced stage and can therefore be costly to rectify. The proposed solutions look at addressing the key measurable outcomes within the functions of a Solutions Engineers. The proposed framework combined with the new organigram therefore looks at equipping the solutions engineer with the skills and confidence to offer the right solution the first time and within the time constraints while pushing the didactic learning systems sales. The need identified is to refocus energy within a specific technology field rather than a geographical area and offer the best solution at all times. It will also enhances collaboration with colleagues in others fields of expertize when offering holistic solutions. Therefore, the need to change arises from the necessity of having specialists aligned with the global product management. The main key performance indexes used to measure the efficiency of a Solutions Engineers are sales of learning systems and the quality of the technical solution provided to the customer. With the proposed framework combined with the realigned organigram the Solutions Engineer will be the expert in his technology area developing market penetration and retention strategies.

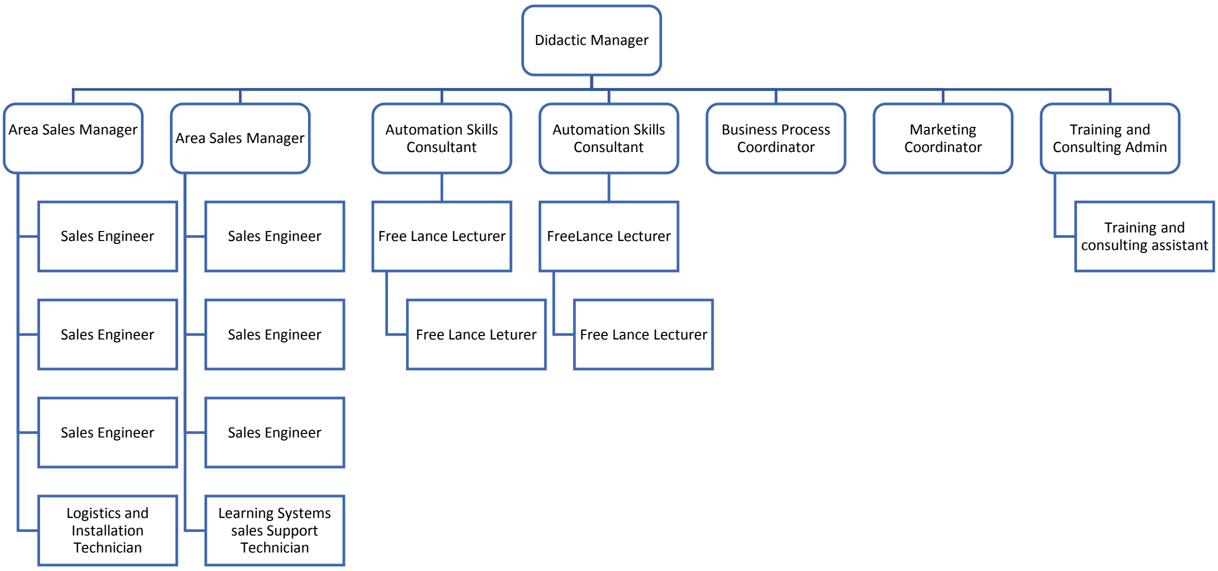

Figure 5: Current Organigram

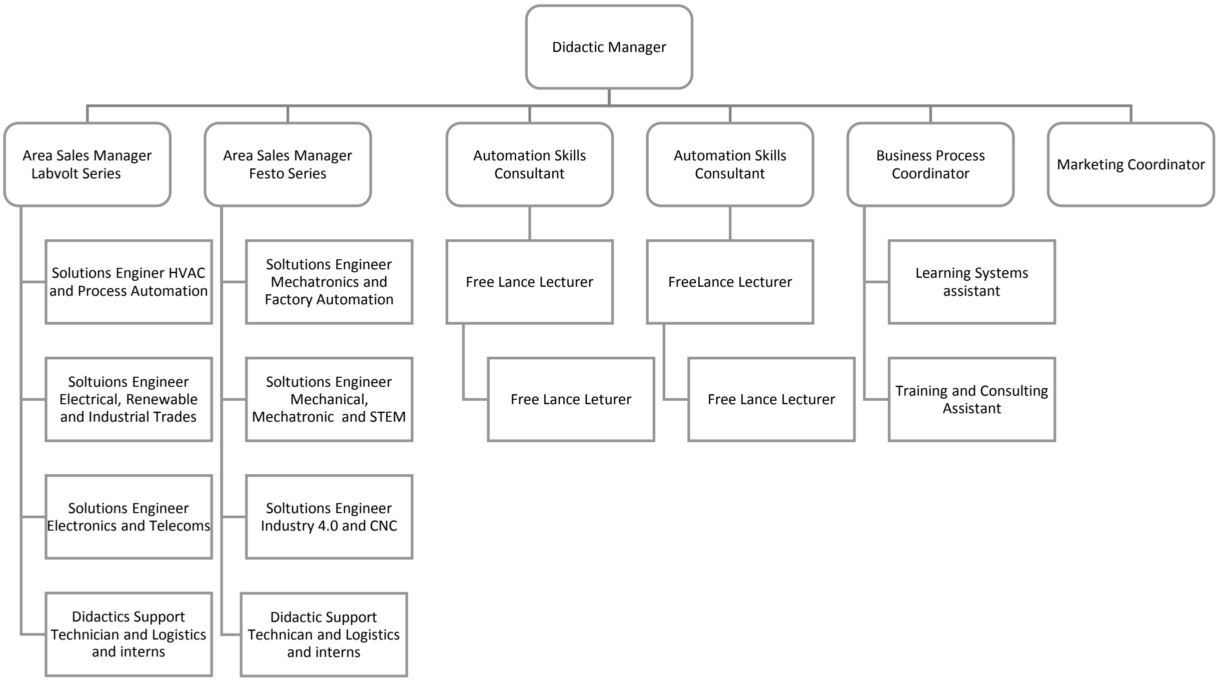

Figure 6: Proposed Organigram

Conclusion

Understanding the daily challenges faced by the Didactic Solutions engineer within Festo South Africa was the central motive for this research study. The framework to optimize the main key measurable outcome of the functions of the didactic solutions engineer within the South African market was presented in this paper. In conclusion, this study has shown that although the current structure and mode of operation can achieve target, it is necessary to improve the system by finding ways of doing things more effectively. One way of doing that is by putting people at the centre of the process.

Recommendation and Future research

The model can be further refined and optimized with more parameters taken into consideration. The following recommendations are suggested from this research study:

- To look at project and tender selection methods using engineering economics models.
- To implement the recommended framework and publish the results with real data.
- Management in high skills environment with a variety of challenges.
- Product based organigram and region based organigram.
- Another research can be done on the same topic integrating the ERP (Enterprise Resources Planning) business processes for Learning Systems and Training and consulting activities.

Acknowledgments

The authors acknowledge the financial support of Festo South Africa and resources made available by the University of Johannesburg.

References

Anderson, N., & Nolte, W. (2005). Systems Engineering Principles Applied to Basic Research and Development. Atlanta: Space Systems Engineering conference .

Arndt , A., & Harkins, J. (2013). A framework for configuring sales support structure. *Journal of Business & Industrial Marketing, 28*(5), 432.443.

Artigue, M., & Perrin-Glorian, M.-J. (1991). Didactic Engineering, Research and Development Tool: Some Thoretical Problems Linked to this Duality. *For the Learning of Mathematics, 11*(1), 13-18.

Asbjornsen , O. (1999). Industrial Ecology and Systems Engineering- a Perfect Match? *INCOSE International Symposium, 9*, 22-28.

Blanchard , B., & Fabrycky, W. J. (1990). *Systems Engineering and Analysis* (fourth ed.). Pearson International Edition.

Blaxter, L., Christina, H., & Malcolm, T. (2010). *How to Research* (Fouth Edition ed.). Berkshire: Open University Press : McGraw-Hill Education.

Botha , B. (2016). Systems Engineering as integrator between engineering and business. Erie, PA: Frontiers in Education Conference (FIE) , 2016 IEEE.

Dombrowski, U., & Malorny, C. (2016). Proces Indentification for Customer Service in the field of the After Sales Service as a Basis for "Lean After Sales Service"s. *Precedia CIRP, 47*, 246-251.

Dwight, R., & El-Akruti, K. (2009). The role of asset management in enterprise strategy success. *ICOMS , Asset Management Conference*, (pp. 68-76).

Forsberg, K., & Mooz, H. (1992). The relationship of systems engineering to the project cycle. *Engineering Management Journal*, 36-43.

Khalid, A. (2013). Systems Engineering Graduate research as Part of Curriculum - Summary of Research. *Procedia Computer Science*, *16*, 967-975.

Krueger, M., Kevin, F., David , W., R. Douglas, H., & Cecilia, H. (2010). *Systems Engineering Handbook: A guide for System Life Cycle Processes and Activities* (3.2 ed.). San Diego: INCOSE.

Locatelli, G., Mancini, M., & Romano, E. (2014). Systems Engineering to improve the governance in complex environments. *International Journal of Project Management, 32*(8), 1595-1410.

Magerhol, F., Aspen, A., Ellingsen, H., & Margrethe, D. (2013). Systems Engineering as a holistic approach to life cycle designs. *Ocean Engineering, 62*(1 April), 1-9.

Magerholm FET , A. (1997). *Systems Engineering Methods and Environmental Life Cycle Performance Within Ship Industry.* Trondheim: PHD Thesis, Norvegian University of Science and Technology, Norway.

Magerholm FET , A. (1997). *Systems Engineering Methods and Environmental Life Cycle Performance Within Ship Industry.* Trondheim: PHD Thesis, Norvegian University of Science and Technology, Norway.

Magerlhom, F., Schau, E., & Haskins, C. (2010). A framework for environmental analyses of fish food production systems based on systems engineering principles. *INCOSE, 13*(2), 109-118.

Onwubolu, G. C., & Badu, B. (2004). *New Optimization Techniques in Engineering* (1st ed.). Berlin: Springer.

Patton , M. (1990). *Qualitative Evaluation and Research Methods* (2nd ed.). Beverly Hills: Thousand Oaks US : Sage Publications.

Sanders, A., & Klein, J. (2012). Systems Engineering Framework for Integrated Product and Industrial Design Including Trade Study Optimization. *Procedia Computer Science, 8,* 413-419.

Sun, W., Kramer, B., Li, Z., & Stuart, J. (2014). A Review of the Commercial Trainers and Experiment Kits for Teaching Renewable Energy Manufacturing. Joint International Conference ISBN 978-1-60643-379-9.

Sung, H. (2005). *Contructing Effective Questionnaires.*

Tchoshanov, M. (2013). *Engineering of Learning: Conceptualizing e-Didactics* (Svetlana Knyazeva, UNESCO Institute for Information Technologies in Education ed.). Moscow: UNESCO institute for information Technolgies in Education.

Vakhtina, E., & Vostrukhin, A. (2014). Didactic Designing of Resource Support For Training Environment. *International Journal "Information Technologies & Knowledge", 8*(3), 255-263.

Yin, R. (2009). *Case study research. Design and methods.* (Fourth ed., Vol. 5). (Sage, Ed.) Applied social research methods series.

Zohrabi, M. (2013). Mixed Method Research: Instruments , Validity, reliability and reporting findings. *Theory and practice in Languages Studies. 3,* pp. 254-262. Findland: Academy Publisher.

Biography

Serge Tankam, a qualified and experienced Electrical Engineering technologist with over 7 years working experience, is a graduate of Tshwane University of Technology in Pretoria (South Africa) with a B. Tech in Electrical Engineering (with major in Electronic, Signal processing, Control systems and telecommunications). He is currently in the process of

completing a Master Degree in Engineering Management at the University of Johannesburg under the supervision of Dr Botha.
Serge is employed as a Didactic solutions engineers at Festo South Africa, where he oversees their operations in seven African countries. He manages and offers state of the art training solutions in different areas of engineering, including: Telecommunications, automation industry, Motor Drives, Electrical Wiring, Servo, Pneumatic, Hydraulic and Mechatronic Systems technology. His current research interests are in System Engineering and its application to business process optimization and customer satisfaction.

Dr Botha started his engineering career as systems engineer at Denel in 1992 and registered as professional engineer with ECSA in 1994. He joined Potchefstroom University in 1994 where he lectured at both under and post graduate level till 2008. In parallel he acted as consultant to PBMR and quality manager to M-Tech Industrial. He completed his Ph.D. in Engineering in 2003 at the North-West University. In 2008 he joined PBMR full time as Senior Systems Engineer. After the closing of PBMR in 2010 he joined the University of Pretoria lecturing in Reliability Engineering, Reliability Based Maintenance and Mechanical Design as part of the Maintenance Engineering programme. He then joined SNC-Lavalin as Design Manager until SNC-Lavalin closed their South African office due to the slump in the mining industry. He is currently a lecturer in Mechanical Engineering Sciences at UJ where he lectures in Design and provides study guidance at post graduate level. Further information can be obtained from Dr Botha at bwbotha@uj.ac.za or from the website of the Department of Mechanical Engineering Sciences at the University of Johannesburg.